BAGLEY, W. C.

CORRELATION OF MENTAL AND MOTOR ABILITY IN SCHOOL CHILDREN

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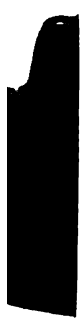

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Approved:

Joseph Jastrow

Professor of Psychology.

June 6. 1898.

A STUDY IN THE CORRELATION

OF

MENTAL AND MOTOR ABILITY IN SCHOOL CHILDREN.

BY

WILLIAM CHANDLER BAGLEY

A THESIS SUBMITTED FOR THE DEGREE OF

MASTER OF SCIENCE

UNIVERSITY OF WISCONSIN

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-Note-

Tne tests which constituted the basis of this study were made upon children in the fourth, fifth, sixth, seventh and eighth grades of the Fifth Ward School, Madison. Through the kindness of Superintendent R.B.Dudgeon and the Board of Education, the apparatus necessary to the investigation was set up in the school building and the tests conducted during school hours. The thanks of the writer are due to the principal, Miss Jones, and her assistants, as well as to Superintendent Dudgeon and the Board of Education for their courtesy in permitting the schools to be put to this use and for their encouragement and assistance both in word and in spirit.

-I-

-Introduction-

The relations which exist between the purely mental and the purely physical are matters of common discussion, ---of a discussion which, although it seldom partakes of a strictly psychological nature and is almost never based upon accurate data, is too common to render necessary an excuse for a study of this kind. The problem, vital as it is to the philosopher and the psychologist, finds its practical bearing in the educational world. The tendency toward the dominance of the university spirit by the athletic element and the rapid extension of the physical culture and manual training courses in the common schools are instances of the change of educational principles with the development of more nearly exact knowledge concerning the true relations of the mental and the physical. It has been our aim to add an incre-

ment to the sum of this knowledge; as to our success or our failure the following pages will speak. It may be well, however, to say in advance that the conclusions we have reached are based upon data far too insufficient in amount to admit of wide generalization. Perhaps we may claim our work more as a suggestion of what may ultimately be accomplished than as a contribution of real value to the knowledge of the subject.

The motor and the mental phenomena with which psychology deals have been treated from many standpoints and by many different methods. The conclusions that have been reached have been applied indiscriminately in the treatment of educational problems without much serious thought as to the reliability of the data from which they have been drawn. The great bulk of these principles are little better than apriori judgments and the majority of the remainder are inductions based upon casual and unscientific observation. Only in a few rare instances have attempts been made by quantitative methods

to reach conclusions which will stand the test of logical analysis. Dr. Bryan (a) has studied motor ability in school children with especial reference to the peculiar conditions which influence it, such as fatigue, practice, age, etc. Hancock (b) and Gilbert (c) have supplemented Bryan's investigations, and in two notable cases---the investigations made in St. Louis (d) on the relation of weight of school children to class standings, and those conducted in Toronto upon the same basis---have correlation studies been made to determine the inter-relations of mental ability and physical conditions. The two last named studies are at variance with each other in their results, the conclusions of the one going to prove that mental and motor ability are inversely related, the other that they are directly related. We cannot presume that our studies will settle the point in controversy, but we may reasonably hope that they will throw some light upon the problem. We at least claim

the following points as worthy of consideration in estimating the relative value of the tests from which we have drawn our data:

1. The number and variety of the tests. Not one test alone has been made the standard by which ability either mental or motor has been judged, but the results of five different tests representing five different types of movement have been combined in such a way as to give a mathematical symbol representing an index of motor ability for each subject, and the several mental tests have been treated in a similar manner.

2. The strictly quantitative treatment of the material. Every attempt has been made to reduce each element of the investigation to quantitative terms thus bringing to bear upon the conclusions all the strength which a mathematical treatment can impart.

With this brief survey of the problem, we shall now pass to a more detailed account of plan and the progress of the tests, beginning with an enumeration of sources.

-II-

-Sources-

The data of this study are drawn from four largely independent sources, two sources contributing the motor data and two the sensory or mental data; of each of these, one source was experimental, the other non-experimental.

1. The Experimental Sources.

(a') Motor. The motor data ~~was~~ were obtained experimentally by means of tests designed to determine motor ability along five lines: (1) strength, (2) rapidity of voluntary movement, (3) accuracy of voluntary movement, (4) control of voluntary movement or "steadiness" of motor control, (5) amount and character of involuntary movement. The apparatus used to determine these points will be described in detail later. The tests were designed to include the most important factors in motor ability, excellence in motor ability being measured by the strength, accuracy, rapidity and steadiness of voluntary

movements and by the minimum of involuntary movements.

(b') Mental. The experimental sources of the data to determine mental ability consisted of various types of reaction times as representing quantitatively the mental ability of the subject, mental excellence being represented by the alertness of the mind to react appropriately upon given stimuli. These tests, which form the basis of an entirely independent study, were conducted by Miss Agnes Chapman; a complete description of the apparatus and the method will be found in her thesis.

2. The Non-experimental Sources.

(a') Motor. The teachers in charge of the various pupils gave an estimate of the motor skill of the pupils as they had observed it in the process of school work. The subjects were classed as "very clever, "clever", "medium", "awkward", and"very awkward". These terms were later translated into numerical symbols for convenience in manipulation.

(b') Mental. The mental data of a non-experimental nature were derived in two ways: (1) From class standings as recorded in the school registers: the purely motor studies---writing and drawing---were eliminated and the remaining standings averaged upon a scale of 100 as numerical criteria of mental ability. (2) In order to eliminate the error that might arise from a difference in standards used in marking by the several teachers, the estimate of the latter was again recorded, this time the estimate of mental ability independent of the subject's record being taken.

3. Auxiliary Data.

(a') Personal. The name, age, and grade of each pupil tested were recorded and spread upon the records of the tests together with the experimental data.

(b') Anthropometric. As material for possible correlations the following facts concerning each subject were recorded: weight in pounds avoirdupois, height in millimetres,

width of head and length of head, both in millimeters.

-III-

-Apparatus and Method-

The apparatus used in the mental tests will, as has already been stated, be fully described in Miss Chapman's thesis. Following is a description of the apparatus used in the motor tests.

(a') The Test for Strength.

(1) Apparatus. For this test a dynamometer of a peculiar type was specially constructed. Upon a fixed wooden rectangular frame standing about two and one-half feet from the floor a spring balance was so affixed that an upward pull on the lower of a pair of grip handles was transmitted by a lever movement to a spring balance secured upon one side of the frame. This balance was fitted with the usual recording scale but in order to render the readings more exact this scale was

discarded in practice and its pointer utilized to move an arm four inches long, so fixed upon a pivot that the free end described an arc of sufficient size to admit of fine graduations. The scale was then determined empirically and graduated in pounds avoirdupois. (Plate I).

(2) Method. The grip-handles were adjusted by thumb screws to the desired distance varying with the size of the subject; the height of the standard was not adjustable, but two small movable platforms rendered the apparatus available to subjects of all heighths. Each subject was given three trials, being directed each time to grip the handles together as tightly as possible with the right hand. The readings were recorded and averaged.

(b') The Rapidity Test.

(1) Apparatus. "Trilling" a Morse key with the right forefinger was the test used to determine rapidity. The key was connected (1) with a dry battery of two cells and (2) with a recorder. The entire apparatus was securely fastened to a board (18" X 18") which was placed

on a table of the size used in the kindergarten.

(2) Method. The subject was seated in a small chair before the table and directed to trill the key as rapidly as possible. As soon as the subject was able to manipulate the key readily the operator switched in the current which started the recorder. The current was kept ten seconds, at the end of which time the operator opened the switch being careful not to tell the subject to stop until after the switch had been opened. Three records of this type were taken and the results averaged.

(c') The Test for Steadiness.

(1) Apparatus. For this test a complicated scroll-plate was devised as follows: A sheet of tin foil was carefully smoothed out and waxed upon a piece of plate glass. Upon this foil a scroll diagram was first traced and then carefully cut out leaving a slit 1 mm. wide. This slit was continuous through all the complications of the scroll, but for convenience its course was divided into four sections, each representing a peculiar type of

movement which the subject must make when tracing that portion of the scroll. The positive pole of the battery was connected with the edge of the foil, the negative pole with a tracing needle made by inserting a needle in the end of a pencil holder and connecting with the battery by a fine wire.

2. Method. The scroll-plate was fastened upon the board used in the rapidity test, the subject was seated before it, given the pen and directed to trace the pattern, being cautioned that he was to keep to the middle of the slit, every failure to keep away from the foil being recorded by a tap of an electric bell which was thrown into the circuit. The taps of the bell were recorded for each section of the scroll, as well as the time for each section, the total number of taps and the total time.

(d') The Test for Accuracy.

(1) Apparatus. This test was made by a recording target (30cm. X 30 cm.) mounted upon a table (such as the

one used in the last two tests), the target being inclined back to make an angle of 45 degrees with the table-top. The target consisted of a wooden frame with a solid back, the frame being fastened to the back by means of hinges. Into this frame a sheet of paper was inserted having marked upon its center a black "bull's eye" 10mm. in diameter. Back of this were a sheet of carbon paper and a sheet of record paper upon which the impressions were preserved.

(2) Method. The subject was placed two meters away facing the target and prevented from approaching nearer by a movable upright. He was given ten marbles and directed to toss them one at a time, attempting to strike the bull's eye at each trial. After the ten marbles had been thrown, the sheet was removed (after first receiving an impression of the "bull's eye" for reference in later measurements). This process was repeated twice, making three records in all.

These records were treated with two different ends in view. In the first place, the distance of each impression from the center was measured in millimetres, an the constant error for each sheet determined. The constant errors of the three sheets belonging to each subject were then averaged and the result recorded as an index of motor accuracy. Then the per cent. of average error was computed for each sheet, the three percentages of each subject being again united as an index of constancy of motion.

(e') The Test for Amplitude of Involuntary Movement.

(1) Apparatus. The apparatus used for determining the amplitude of involuntary movement was the automatograph designed by Professor Jastrow and known by his name. A full description will be found in the literature of contemporary psychological discussion. (e)

(2) Method. The automatograph was set upon the table, the subject being directed to stand before it in such a

position that the median plane of his body made an angle of 45 degrees with the edge of the automatograph opposite the recording pencil. The attention of the subject was then concentrated upon a metronome placed upon a table two metres in front of him. This metronome was set at 120 beats per minute and the subject directed to count the beats up to 120, raising his right hand and resting it, tips of the fingers down, upon the upper plate of the automatograph when he began to count. At the same time the operator dropped the pencil upon the recording plate, leaving it there until the subject had completed his counting. Three records of this kind were taken. The total amplitude of movement was measured upon each record by means of a sliding compass, the average of the three record amplitudes thus obtained being taken as an inverse index of the subject's excellence in the test. While every precaution was taken to make these measurements as exact as possible, they must still be interpreted rather as approximations than as exact determinations.

-IV-

-Results-

The tests were begun December 13, 1897 and continued daily (during the school sessions) until the first of May. Each test occupied from twenty-five to forty-five minutes, the average being about thirty-five minutes. In all one hundred and sixty tests were made for motor ability and one hundred and seventy-five for mental ability (reaction-times). Of the two tests, one hundred and ten of each were upon the same pupils, giving a basis for a correlation study. For both tests the additional data were collected from the school records and from the teachers' estimates as described in the section on sources, but only for those who underwent the motor tests were anthropometric data tabulated.

Method of Treating the Data. The entire motor, personal and anthropometric data were spread upon four large sheets of ruled paper. In this way the material

was arranged in such a manner as to render it easy of manipulation. To the data as thus arranged were added from time to time the class standings of the subjects as obtained from the teachers' registers and the teachers' estimates of mental and motor ability as translated into numerical terms, together with "indices" (to be described later) of the mental alertness and motor ability of each subject as gained from the tests upon reaction times.

The data as thus arranged were were first examined with a view to detrmine their general relations. The various columns were averaged and from these averages curves of distribution were plotted. These curves will be found among others in the appendix. (See curves of distribution).

Aside from this general treatment, special correlations were made in the following manner:

The quantitative results of each important test were divided into five classes of thirty-two subjects each, the thirty-two having the highest records in each

case being placed in the first class (designated classAA), the thirty-two having the lowest being grouped in the last class (class XX), while the remaining ninety-six were similarly grouped into three intermediate classes (classes A, M, and X) in the order of their excellence. The data as arranged in this way for each test were spread upon separate sheets (one sheet for each class), and upon these same sheets were also placed the remaining data---mental, motor, personal or anthropometric---which we wished to correlate with the given test, each line of figures across the page representing the results of the same subject in the various tests. The various vertical columns were then averaged and a single correlation was completed.

An example may make the process clearer. We will suppose the results of the dynamometer test to have been arranged in five groups as described. It is desired to correlate with this dynamometer test the standings as obtained from the school registers. Along with the

transfer of the dynamometer standings from the general sheet to the correlation sheet, the class standings are also transferred, the dynamometer record of each pupil being placed upon its appropriate sheet and the class standing of the subject represented being placed in an adjacent column. When the vertical columns are averaged the general average dynamometer standing of the thirty-two subjects who were the best in the test is shown, and beside it is the average class standing of these thirty two best dynamometer subjects. By this means, after averaging the remaining four sheets in the same way, we arrive at what we may term a single or simple correlation, that is, a correlation of five groups of a more or less uniformly varying scale of excellence in the given test with the average class standings of these same groups. From this a curve may be plotted, the five averages of the correlating test being the five points of the curve as measured from one co-ordinate in terms of the five averages of the data with which the given test is correlated.

This method may be complicated by the following process: After making a simple correlation as above, arrange the data which has been correlated with the given test in five similar groups of thirty-two subjects each, arranged in the order of excellence as represented by that data. To continue the above instance: If, after correlating the dynamometer test with the class standings singly as was described, it is wished to make a double correlation, the class standings may be arranged in five classes according to their degrees of excellence. Beside each subject's class standing, his dynamometer test may be recorded. These sheets averaged as before will give the average dynamometer results for each group of subjects arranged in order of class standings. If a curve is plotted from this latter correlation upon the same co-ordinates as the curve of the former correlation and if care is taken to have the order of excellence in each case proceed from left to right upon the abscissa

and from below upward upon the ordinate, the following conditions may be observed:

(1) If the two curves have a general NE (northeasterly) direction (i.e., from the meeting point of the coordinates to the uppper right-hand corner of the cross-section sheet), the correlation is agreeable, i.e., the order of excellence in one case bears a direct relation to the order of excellence in the other case.

(2) If the curves have a general SE (southeasterly) direction (from the lower right hand corner of the cross-section sheet to the upper point of the ordinate) the correlation is antagonistic, i.e., the order of excellence in one case bears an inverse relation to the order of excellence in the other case.

(3) If the curves cross each other at right angles the correlation is indifferent, the degree of indifference depending upon the degree to which the angle approaches ninety degrees.

It may be well to add that these conclusions can be reached

less satisfactorily from the single correlations, the general direction of the single curve giving some index as to the character of the correlation,---always providing the order of excellence is as described above.

This peculiar type of correlation was devised and elaborated by Professor Jastrow and Dr. J.QQuantz in the course of their studies upon the psychology of reading (9-

The Motor and the Mental Indices. The terms "motor index","mental index","reaction-time index" and "handling-time index" appear in several places in the curves and tables. The motor indices were derived as follows: The results of each test were arranged in the precise order of their excellence; the highest was then given an arbitrary value 999, the others, values in orde down to 840 (which exhausted the 160 subjects.) The pre cess was completed for five tests, viz., the tests for rapidity, accuracy and steadiness of voluntary movement, the test for strength, and the test for amplitude of involuntary movement. Then these five motor standings of

of each subject were averaged and an arbitrary symbol obtained which represented the motor ability of each subject. This was called the motor index. Proceeding in the same general way, a mental index was obtained from the results of the mental tests. This mental index represents mental alertness and gives an estimation of mental ability as far as the sensory and central portions of the reflex arc are concerned. The "handling time" index was derived from the mental tests, but is really an index of motor ability, since it gives a numerical estimate of the subject's excellence as represented in the motor section of the reflex arc.

The Teachers' Estimates. These were translated into numerical terms according to the following scheme: Motor ability: Very clever, 5; clever, 4; medium, 3; awkward, 2; very awkward, 1. Mental ability: very [illegible], 5; bright, 5; bright, 4; medium, 3; dull, 2; very dull, 1.

-V-

-Interpetations and Conclusions-

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In the examination of the curves, it will be well to confine our attention first to those of a more general nature, passing ultimately to the particular correlations with which our studies are chiefly concerned.

1. The Curves of Distribution. (Curves of Distribution, A, B, C, D, E, F, G, H, I.)

These curves show the degree of variation in motor ability as represented by the various tests, in mental ability as represented by the class standings, in age, and in physical development as represented by weight and head girth. It will be noticed that the distribution curves have been drawn in such a way that each unit of distance on the ~~ordinate~~ abscissa represents a variation of ten per cent. of the normal or average of the various classes. By this means the various curves have been made comparable.

In general the curves show a rather wider deviation in mental and motor ability than in personal or anthropometric relations. Attention is called to the curves of weight and age as displaying largely uniform variations. The variation in the rapidity and strength tests are not wide, while those in the steadiness test are very wide, indicating a wide difference in the relative motor ability as shown in the different tests.

2. The General Curves of Correlation.

(a) Sex and Age. (See Correlation Curves K, L, M.)

The curves representing the relative ability of boys and girls, both mental and motor, at various ages, lead to the following conclusions: (1) That the boys tested were superior to the girls in motor ability while the opposite relation held in mental ability; (2) that there is a gradual increase in motor ability with age. These results may do something perhaps toward explaining the seeming incongruities that appear in the special correlations.

(b) Anthropometric Measurements compared with Mental and Motor Ability. (See Correlation Curves O and P.)

The curve O representing the correlation of weight and class standings shows a decrease of mental ability with increased weight. This vindicates in a degree the results obtained by Professor Porter in St. Louis. (d) The curve P representing the correlation of mental ability (as shown by class standings) with head girth shows plainly a significant trend in the direction of better scholarship for those having the smaller heads. The curve agrees in general with the curves of weight and age, and may be studied profitably in connection with those curves. The fact, however, that the relation as displayed in Curve P is not the reverse of what it is, is, in itself, significant.

3. The Special Correlations of Mental and Motor Ability.

(a) The Correlation of Motor Ability with Class Standings.

Curve No. I. Class Standings and the Test for Strength.

The double correlation in this case shows a distinctively inverse relation.

Curve No. II. Class Standings and the Test for Rapidity. The curve shows indifference with a tendency toward an inverse relation.

Curve No. III. Class Standings and "Steadiness" Test. Shows a distinct tendency toward an inverse relation.

Curve No. IV. Class Standings and the Test for Accuracy. Shows an inverse relation especially in the central part with a tendency toward a direct relation at the extremeties.

Curve No. V. Class Standings and the Test for Constancy. Shows a tendency toward indifference with a marked inverse relation near the center.

Curve No. VI. Class Standings and the Test for Involuntary Movement. The curve is markedly indifferent with a slight tendency toward a direct relation.

Curve No. VII. Class Standings and Motor Index. The relation is markedly inverse.

(b) The Correlation of Motor Ability with Teachers' Estimates of Mental Abilty.

Curve No. IX. Supplementary Correlation of Teachers' Estimates of Mental Ability and Class Standings. The single correlation shows a general agreement of the estimates with the standings, with a notable antagonism near the center of the curve due perhaps to the charitable tendency of the teacher to overestimate mental ability.

Curve No. X. Teachers' Estimates and Test for Strength The double correlation reveals a general tendency toward antagonism or an inverse relation, with, however, an appreciable variation in the direction of indifference.

Curve No. XI. Teachers' Estimates and the Test for Rapidity. This shows a relation similar to that revealed by the last curve.

Curve No. XII. Teachers' Estimates and the Test for Steadiness. Shows a very slight tendency toward an inverse relation.

Curve No. XIII. Teachers' Estimates and the Test for Accuracy. Shows a slight tendency toward an inverse relation.

Curve No. XIV. Teachers' Estimates and the Test for Constancy. The curve is a type of indifference. Its irregularity makes it extremely difficult to interpret, but its general trend toward indifference seems unmistakable.

Curve No. XV. Teachers' Estimates and the Test for Involuntary Movement. The curve is slightly indifferent but shows a general tendency toward a direct relation.

Curve No. XVI. Teachers' Estimates and Motor Index. This curve shows a general tendency toward an inverse relation.

(c) The Correlation of Mental Alertness as indicated by Reaction times with the Motor Index.

Curve No. XVII. This is the most peculiar and irrational curve of the collection. The general tendency toward an inverse relation would be most evident were it not for the remarkable discrepancy at one point. Whether this is due to an accident or to an error in an earlier

calculation, or whether the discrepancy is the result of a constant variation, are questions which can be decided only by a future test. It seems safe to conclude, however, that, inasmuch as the curve in other respects shows such unmistakable tendencies, we are justified in classing it for the time being with the curves showing an inverse relation.

(d) The Correlation of the Motor Index with "Handling Time" (q.v.)

Curve No. XVIII. This curve shows an agreement between the handling time as expressed in the mental tests and the motor index as derived from the motor tests.

Conclusions from the Special Correlations.

It will be seen that we have drawn our correlating data from three sources as regards mental ability, and from one chief source as regards motor ability. The data

from this last source have been correlated with the data from each of the other three sources. There is a remarkable agreement between all these correlations and this agreement is the more remarkable when it is considered that the three sources of mental data were largely independent of each other. This fact would tend to eliminate any errors of accident that might arise , and it gives to the conclusions a strength which they would not otherwise possess.

In only one correlation,---the correlation of class standings with involuntary movement, and the same correlation in the case of teachers' estimates,---is a direct relation shown between mental and motor ability. In every other test, the relation is either indifferent or inverse, and in the great majority of the instances it is inverse. The correlations of the motor index with both the standings and the estimates show this very plainly.

With all these facts in mind it seems reasonable to conclude that, with the children tested, excellence in

mental ability was, as a rule, accompanied by a deficiency in motor ability, and vice versa. It only remains to add that the tests were too limited in number to permit of a wide generalization of this conclusion. We can offer this only as a preliminary study. We believe that the method, if carried far enough, will bring good results. Its chief deficiency in the present study seems to be that it lacks the strength of numbers.

-Authorities-

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(a) Bryan, W.L. On the Development of Voluntary Motor Ability. Americal Journal of Psychology. Vol. V, No. 2.

(b) Hancock, J. A. A preliminary Study of Motor Ability. Pedagogical Seminary. October, 1894.

(c) Gilbert, J.A. Motor Ability. Studies from the Psychological Laboratory of the University of Iowa.

(d) Porter, W.T. The Physical Basis of Precocity and Dulness Transactions of the Academy of Science. St. Louis, Mo. Vol. VI. pp. 161-181.

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Plate I. Dynamometer used in the Test for Strength.

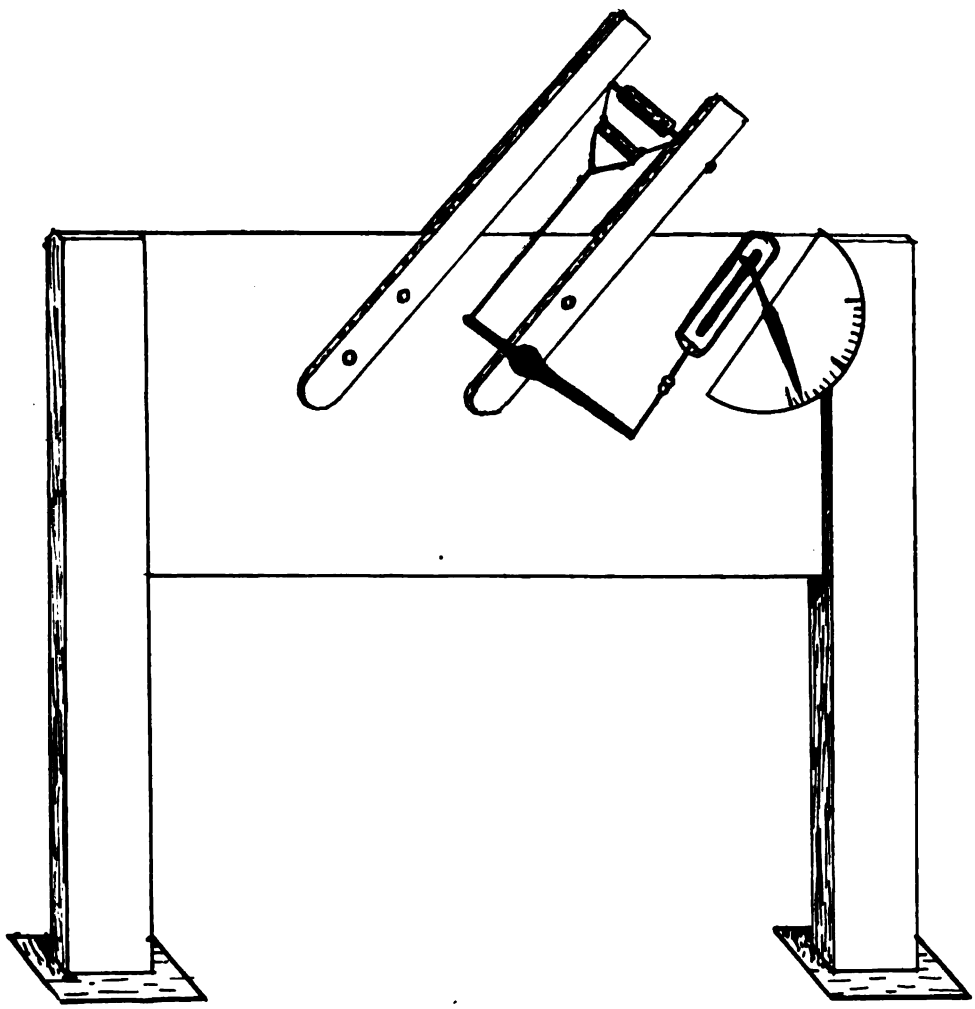
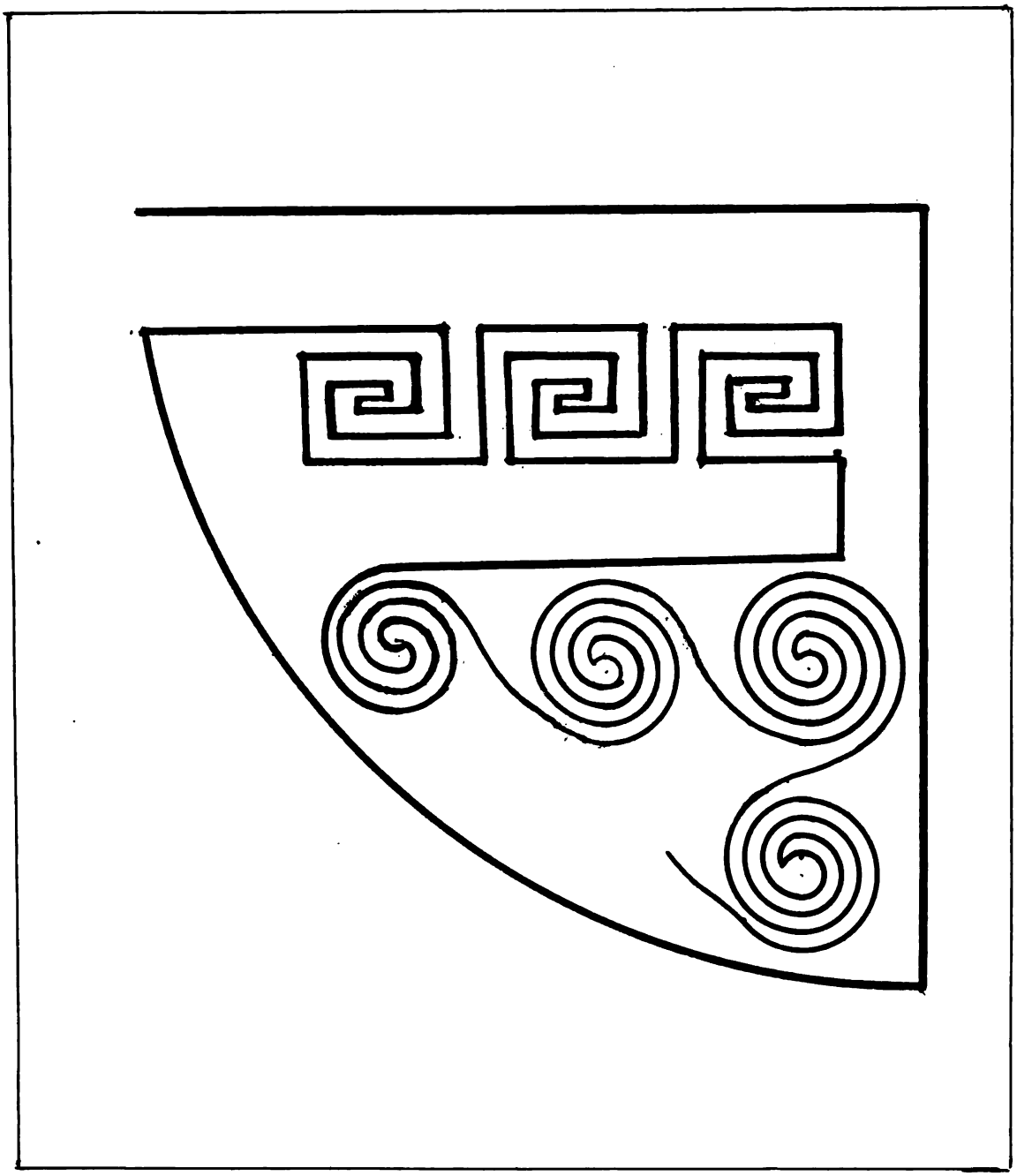
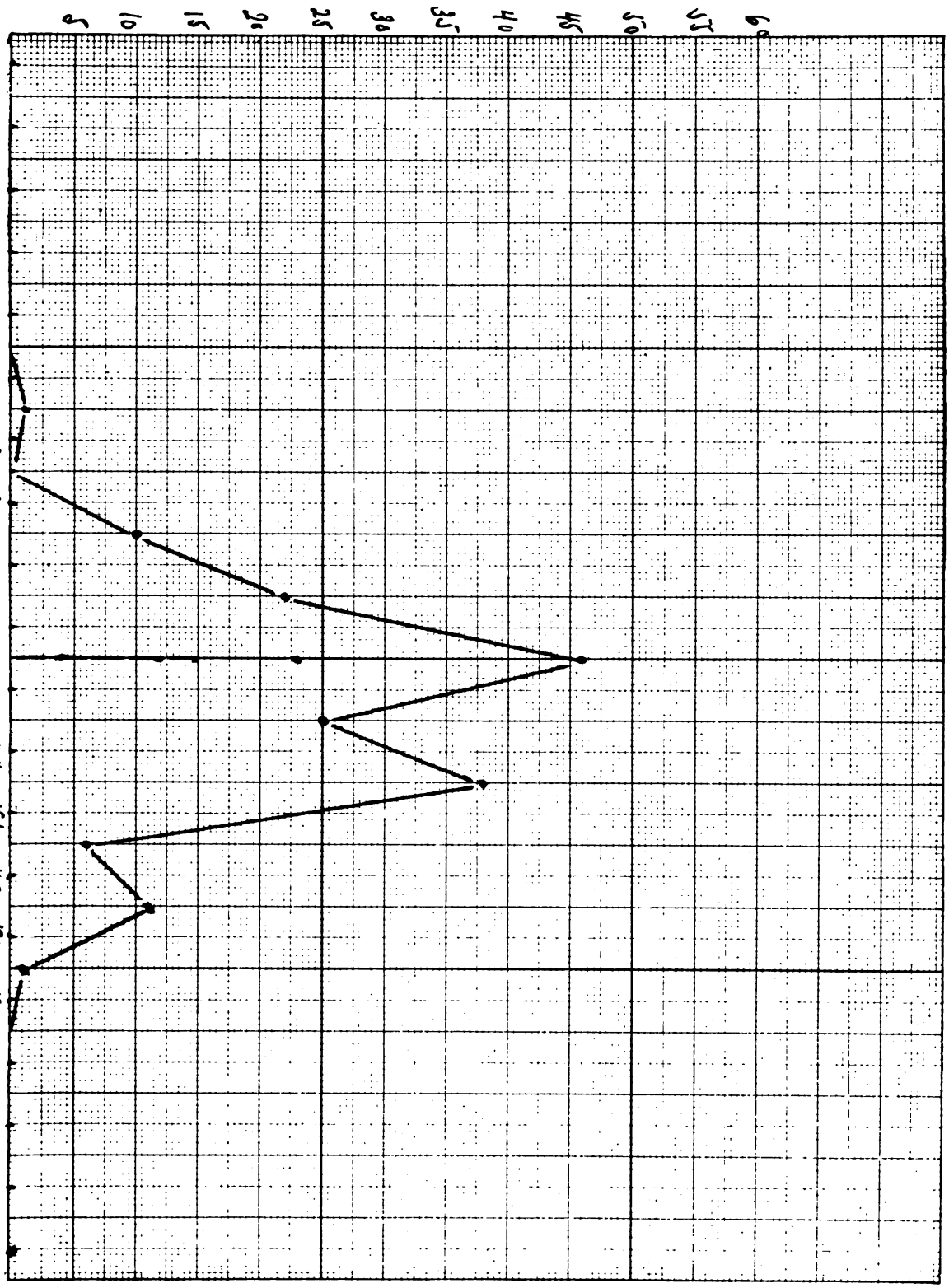


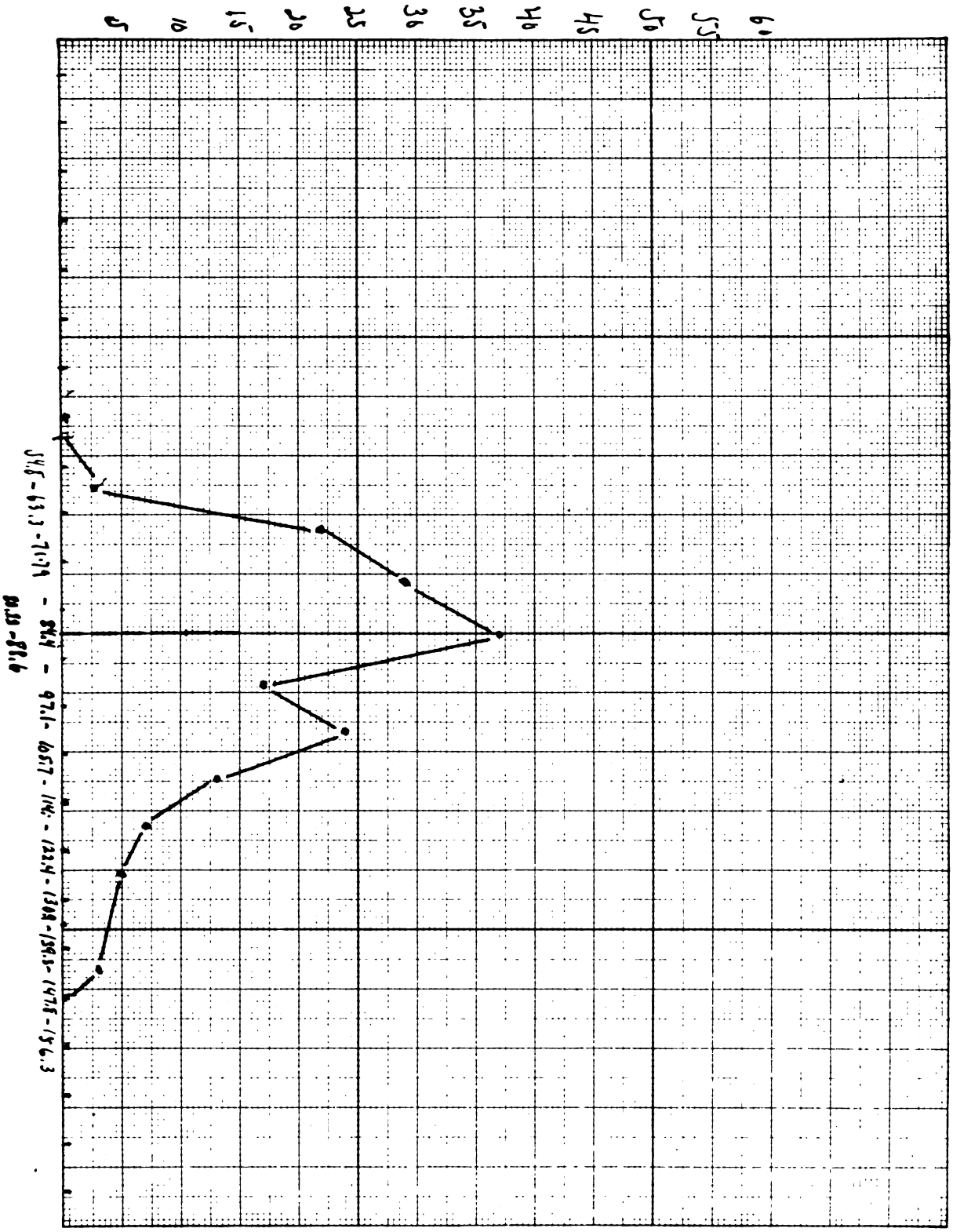
Plate II. Diagram of Tracing Plate used in the Test for Motor Control.



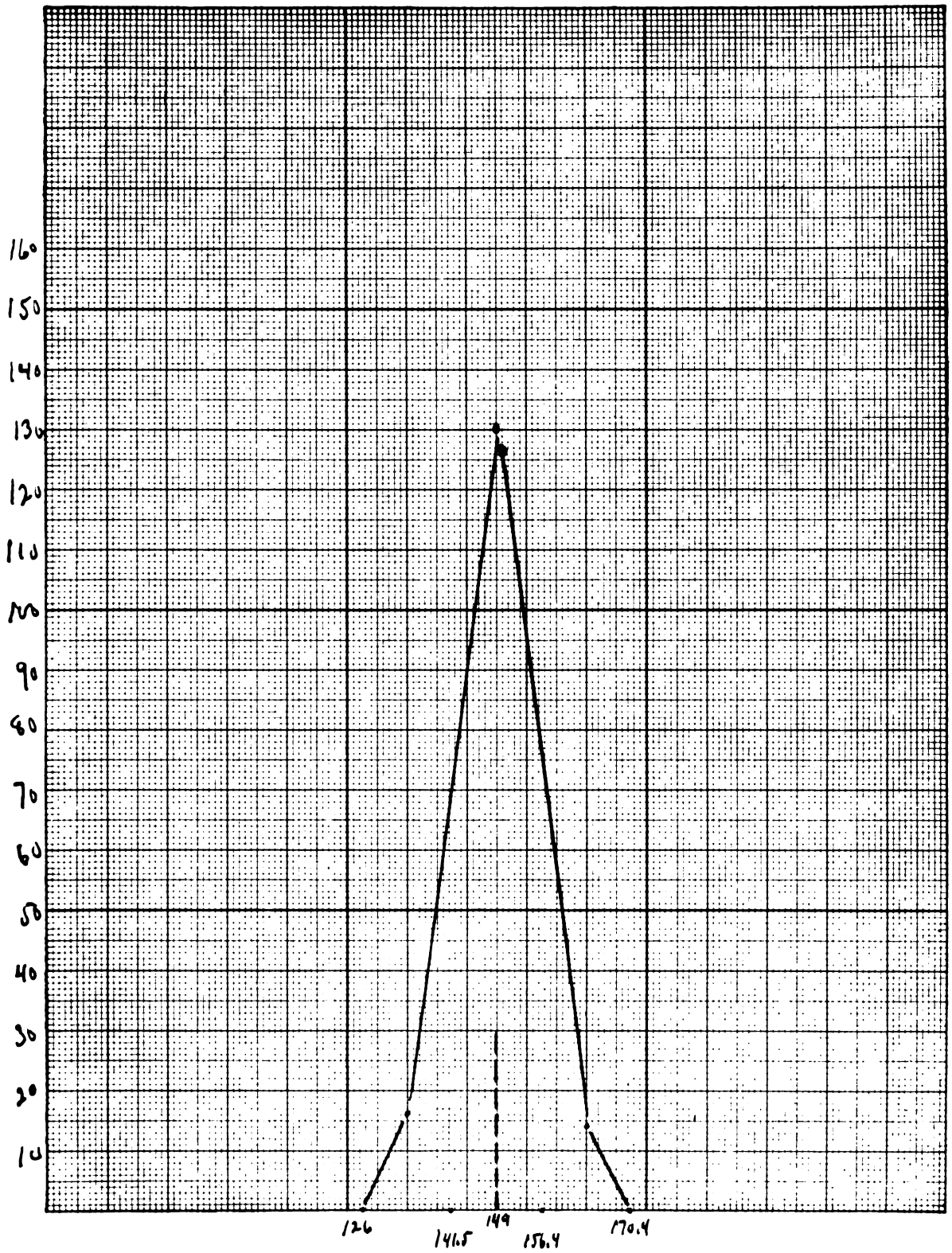
Curve of Distribution A. Variation in Age.



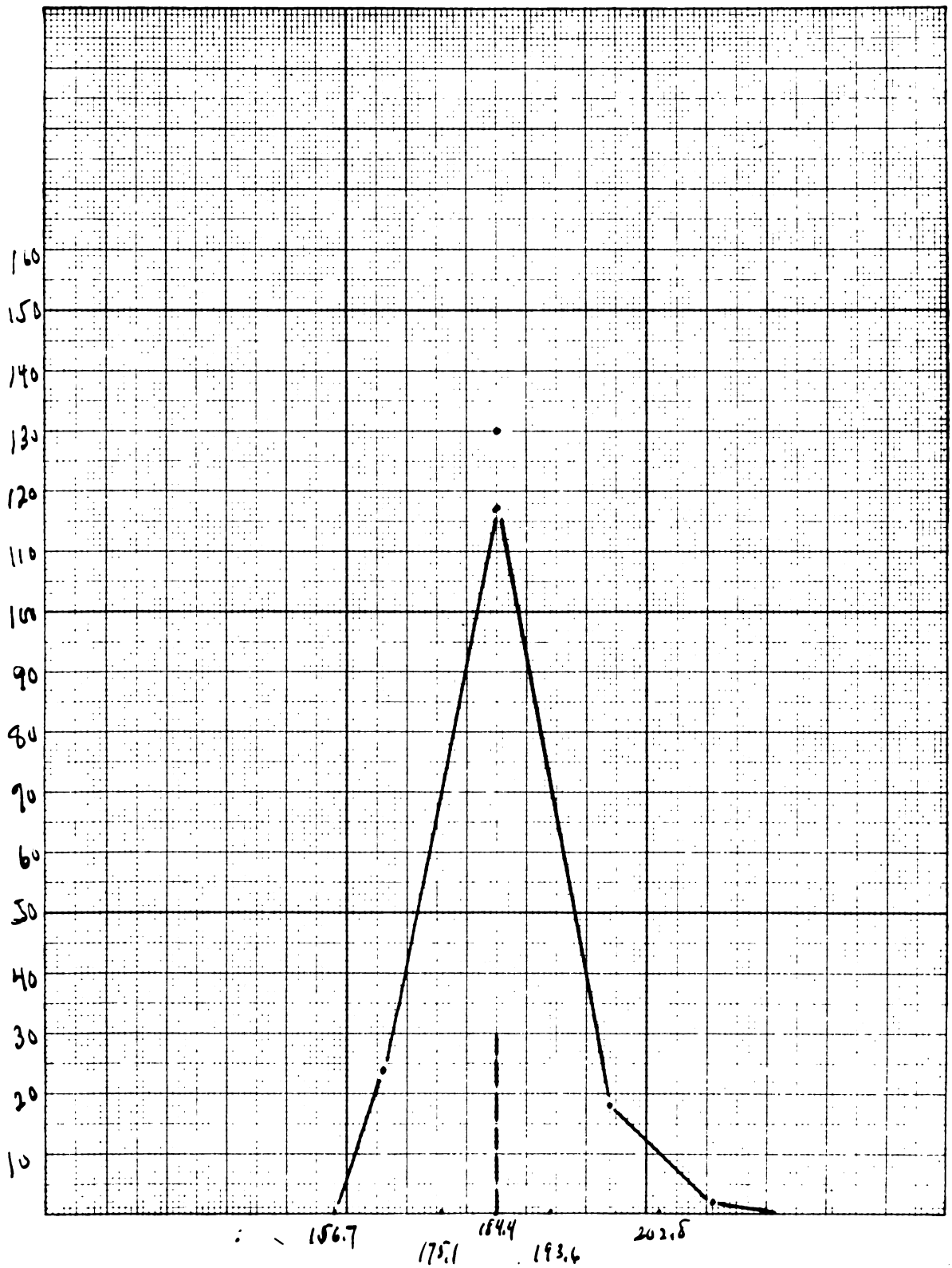
Curve of Distribution, B. Variation in Weight.



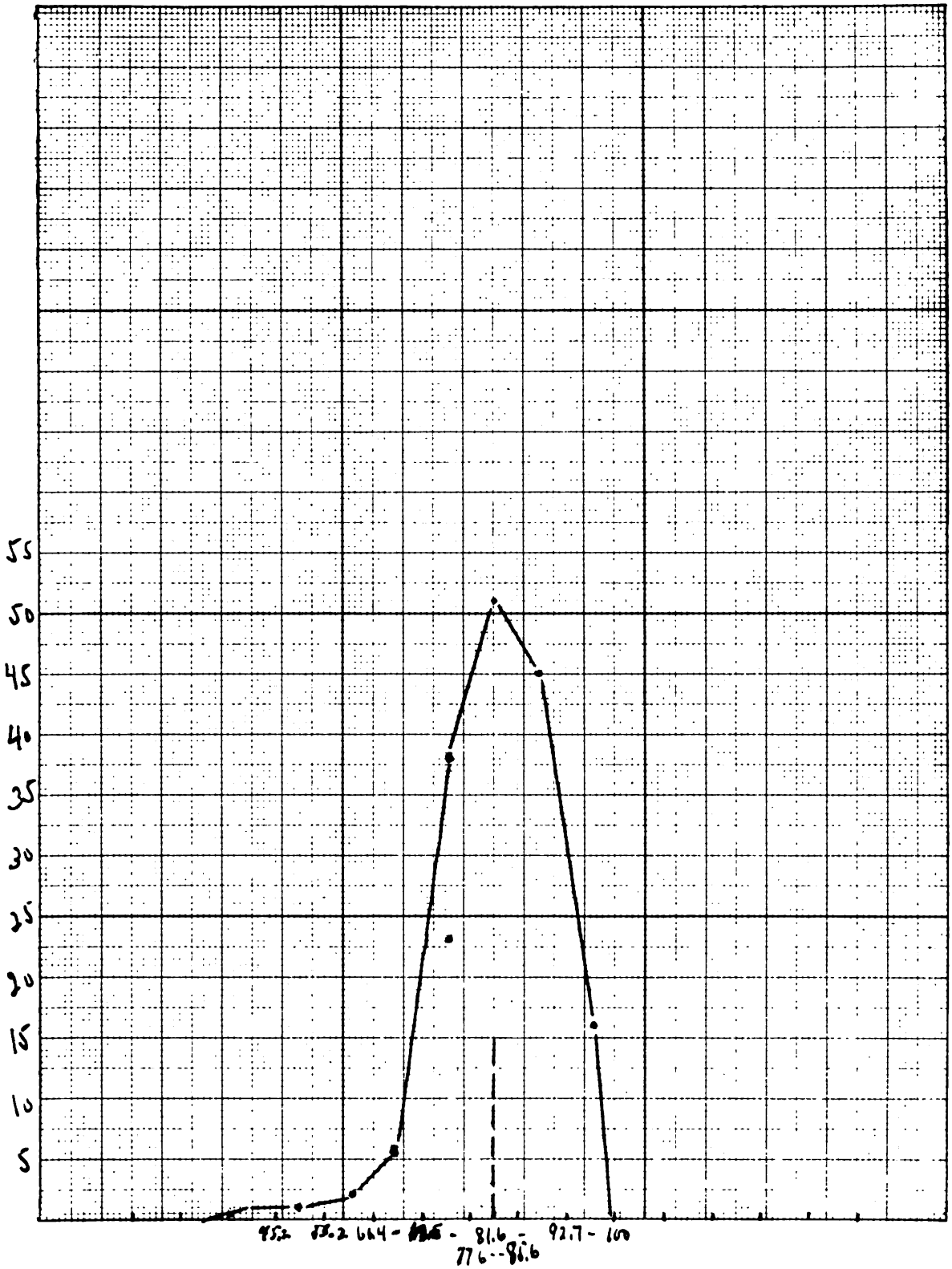
Curve of Distribution, C. Variation in Head Breadth.



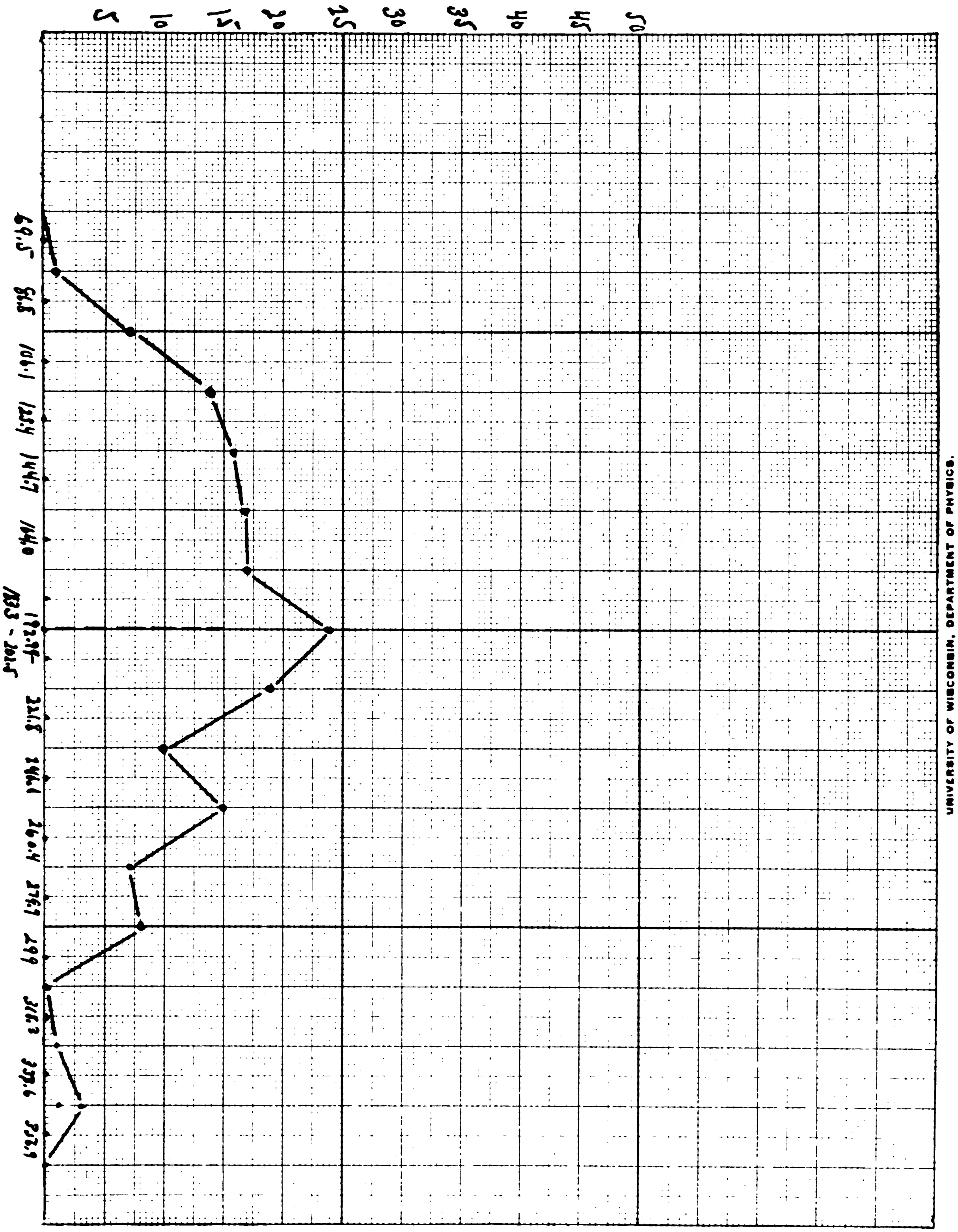
Curve of Distribution, D. Variation in Head Length.

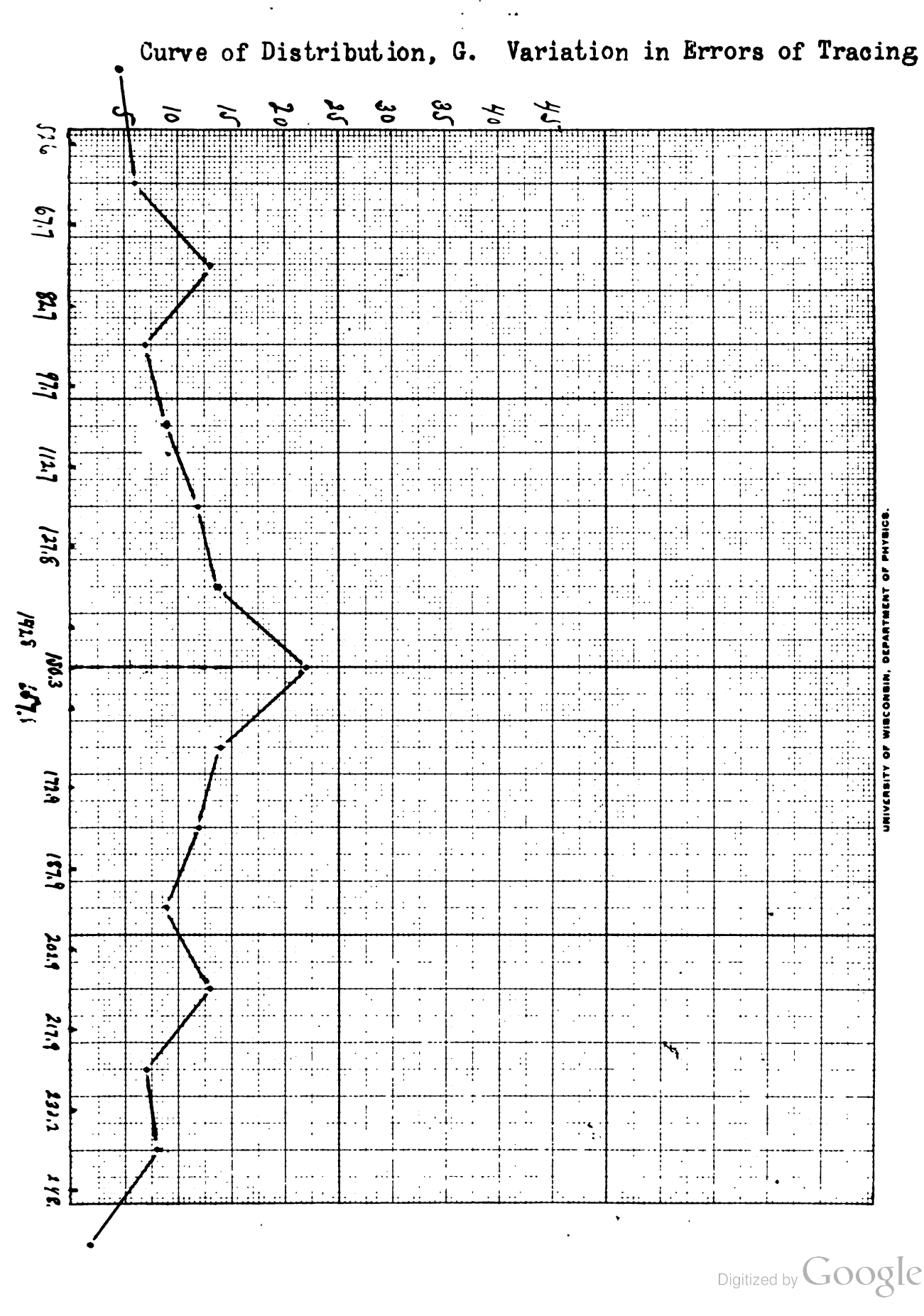


Curve of Distribution, E. Variation in Class Standings.

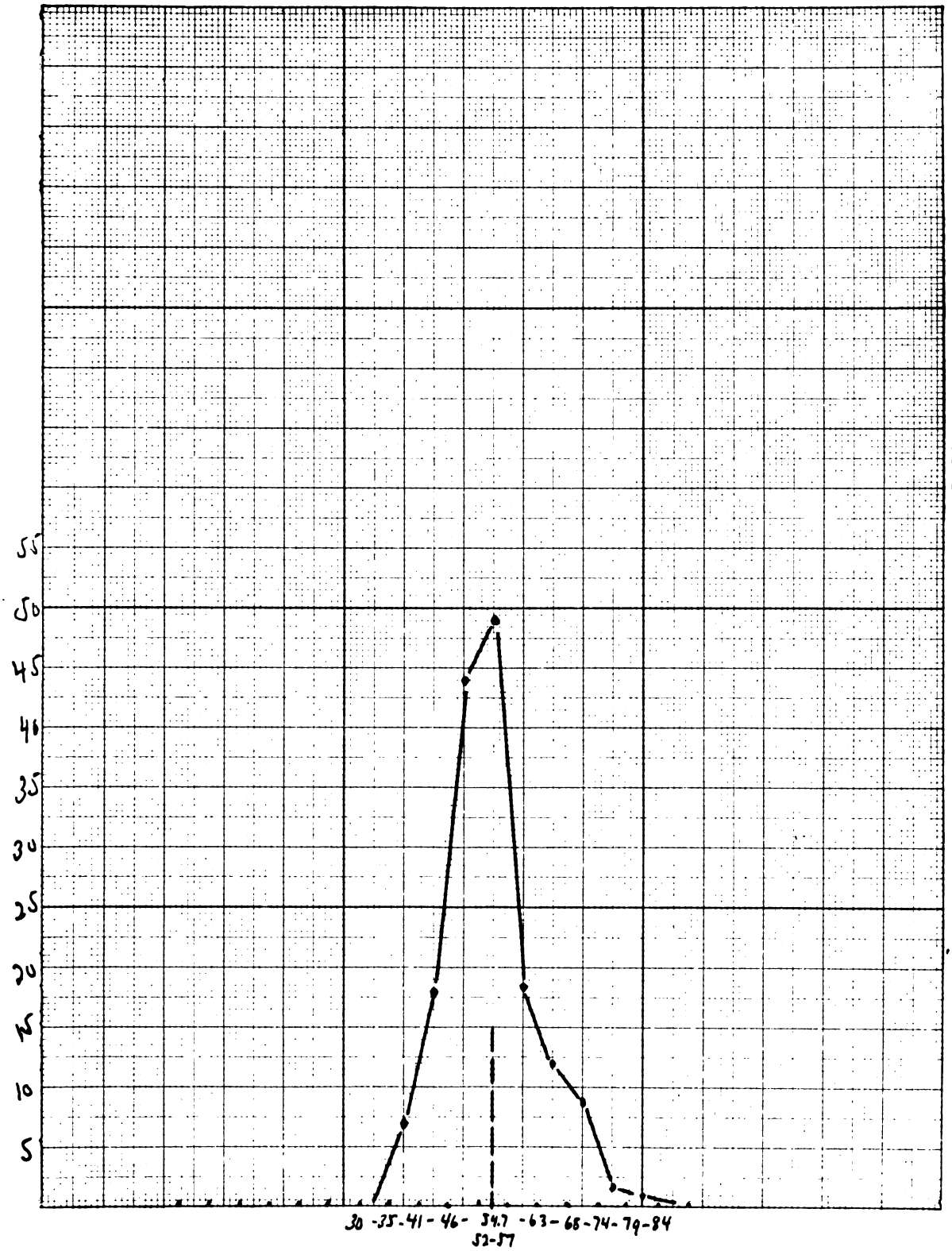


Curve of Distribution, F. Variation in Time of Tracing.

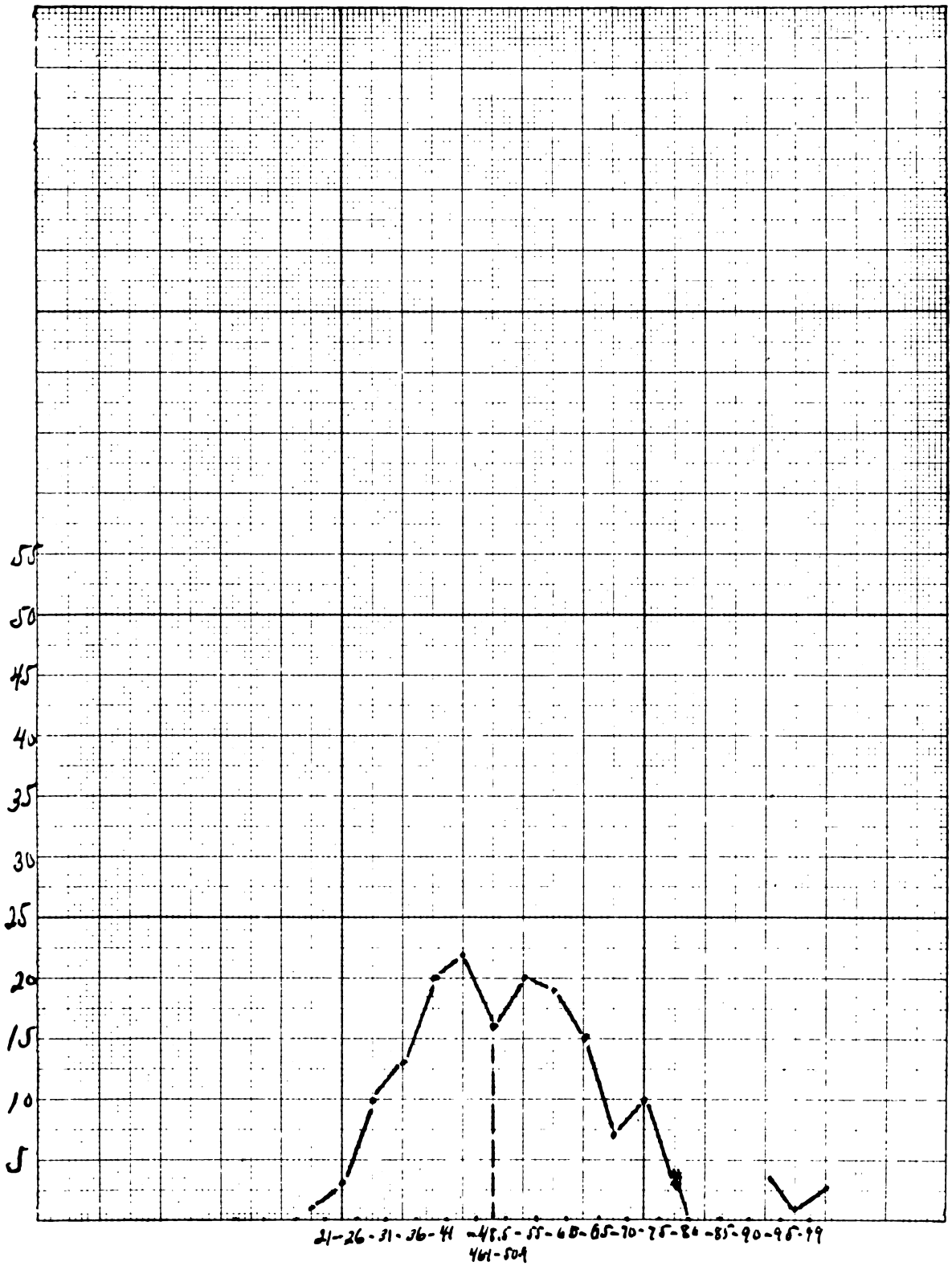




Curve of Distribution, H. Variation in the Rapidity Test.



Curve of Distribution, I. Variation in the Test for Strength



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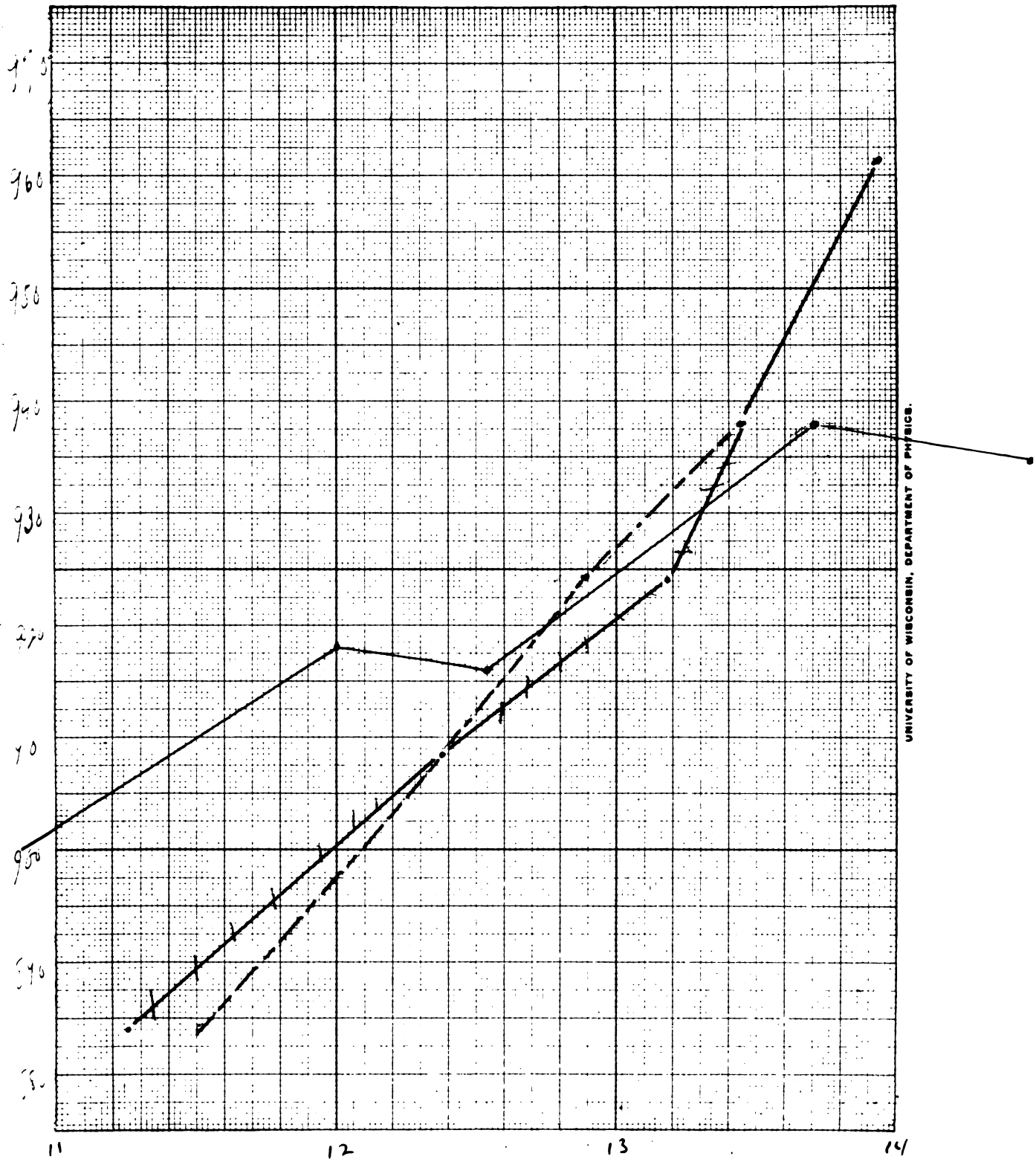
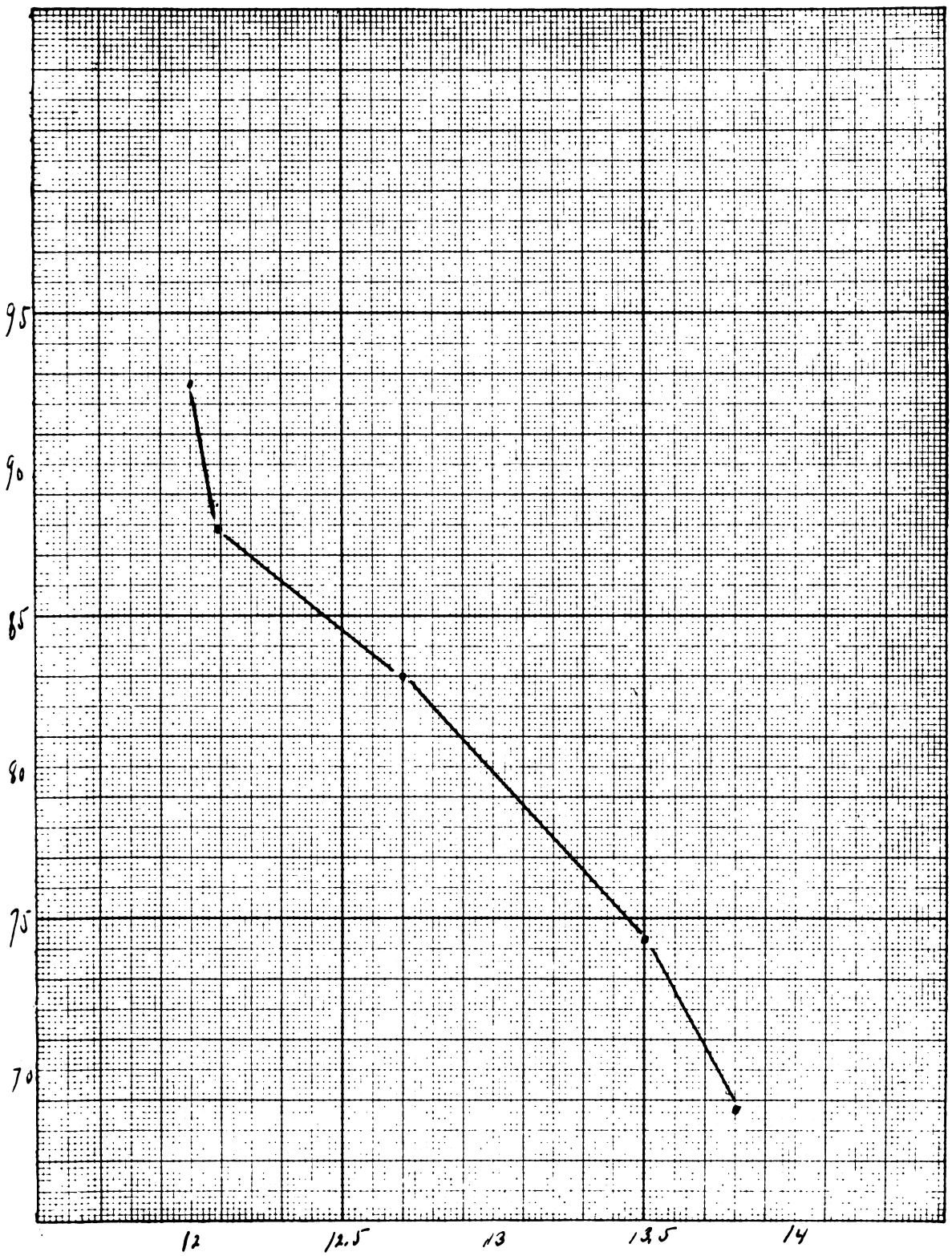
Correlation Curve, K. Single Correlation of Age and Motor Index.



Abscissa: Age.

Ordinate: Motor Index.

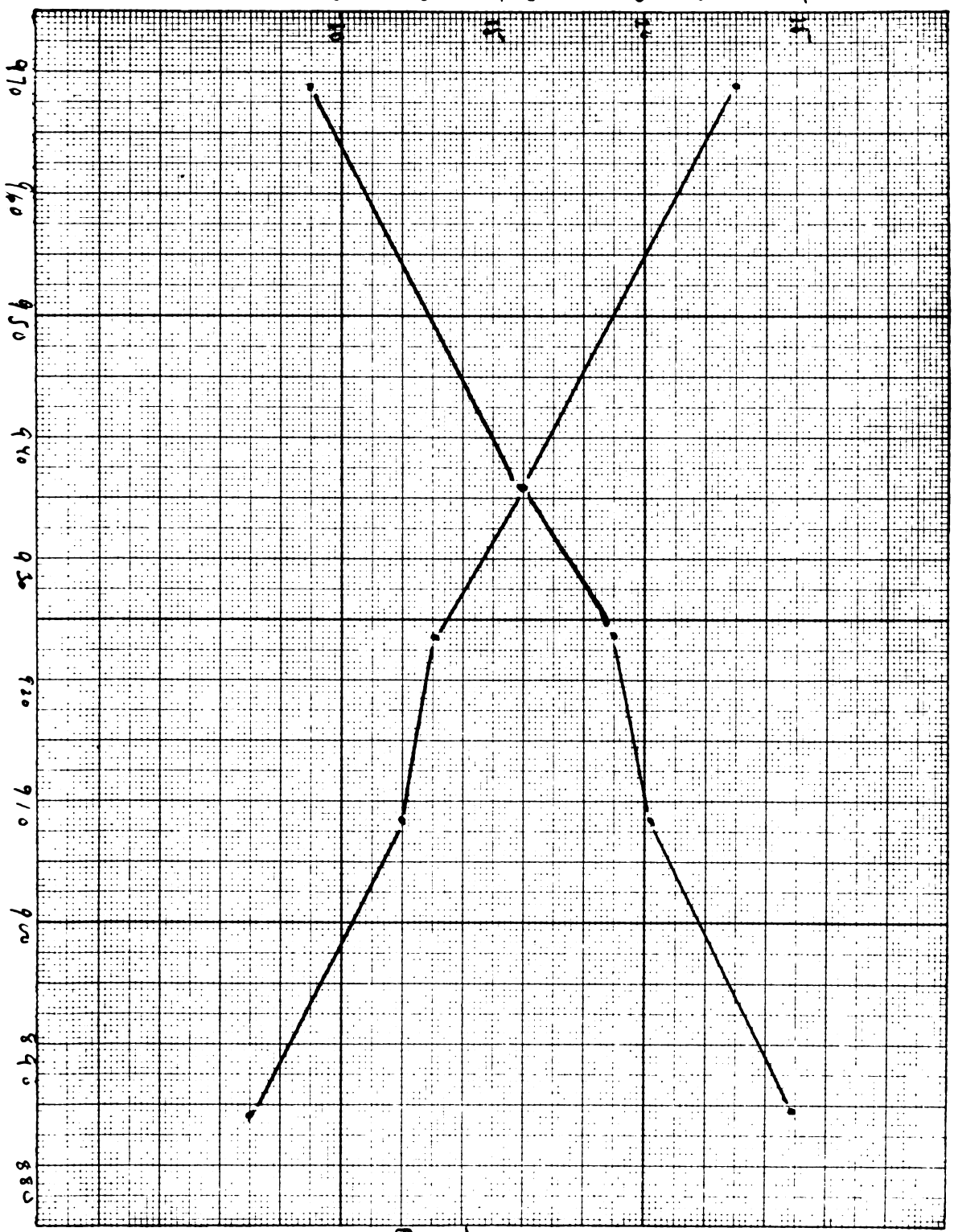
Correlation Curve, L. Single Correlation of Age and Class Standings.



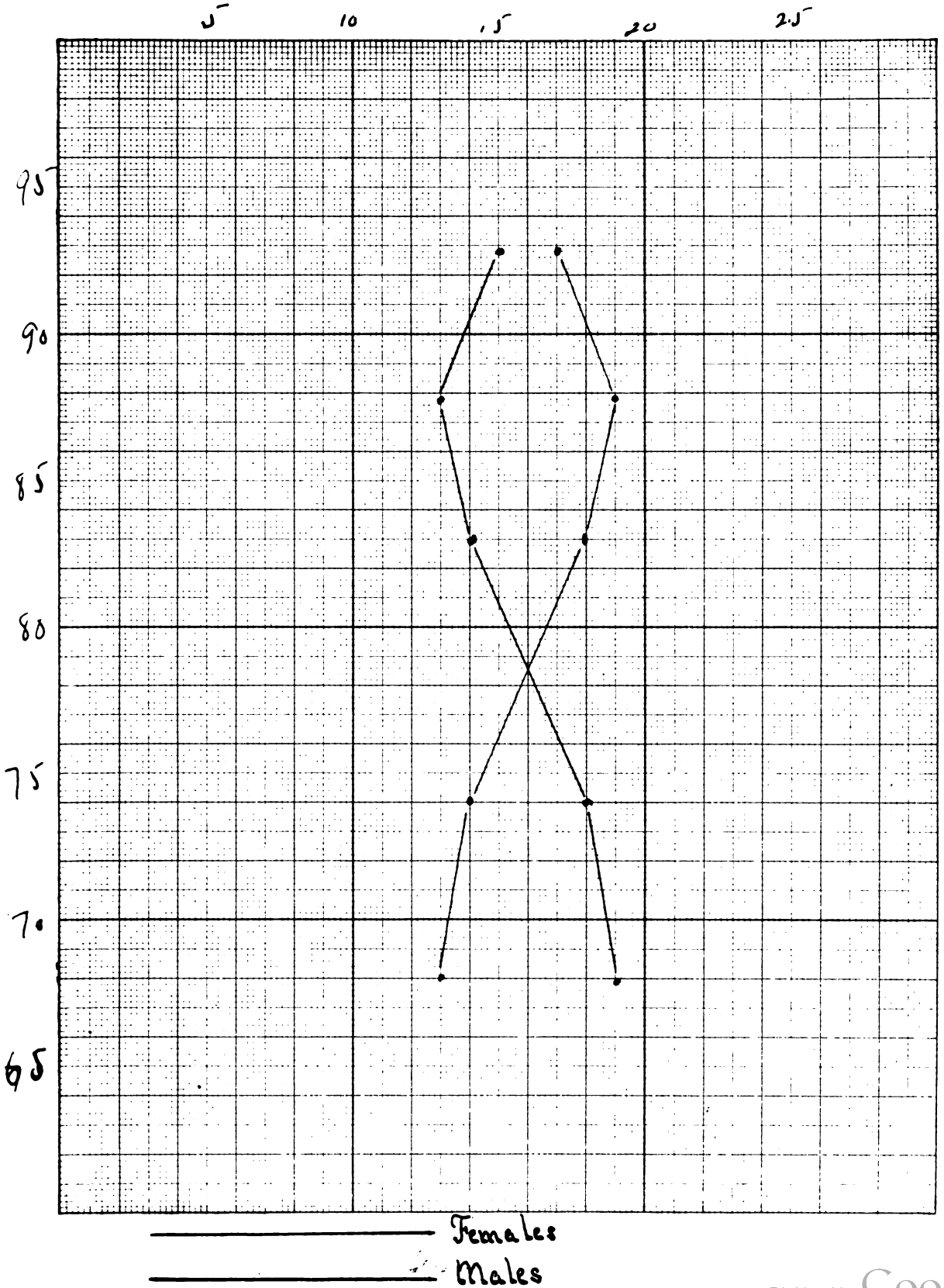
Abscissa: Age

Ordinate: Standings.

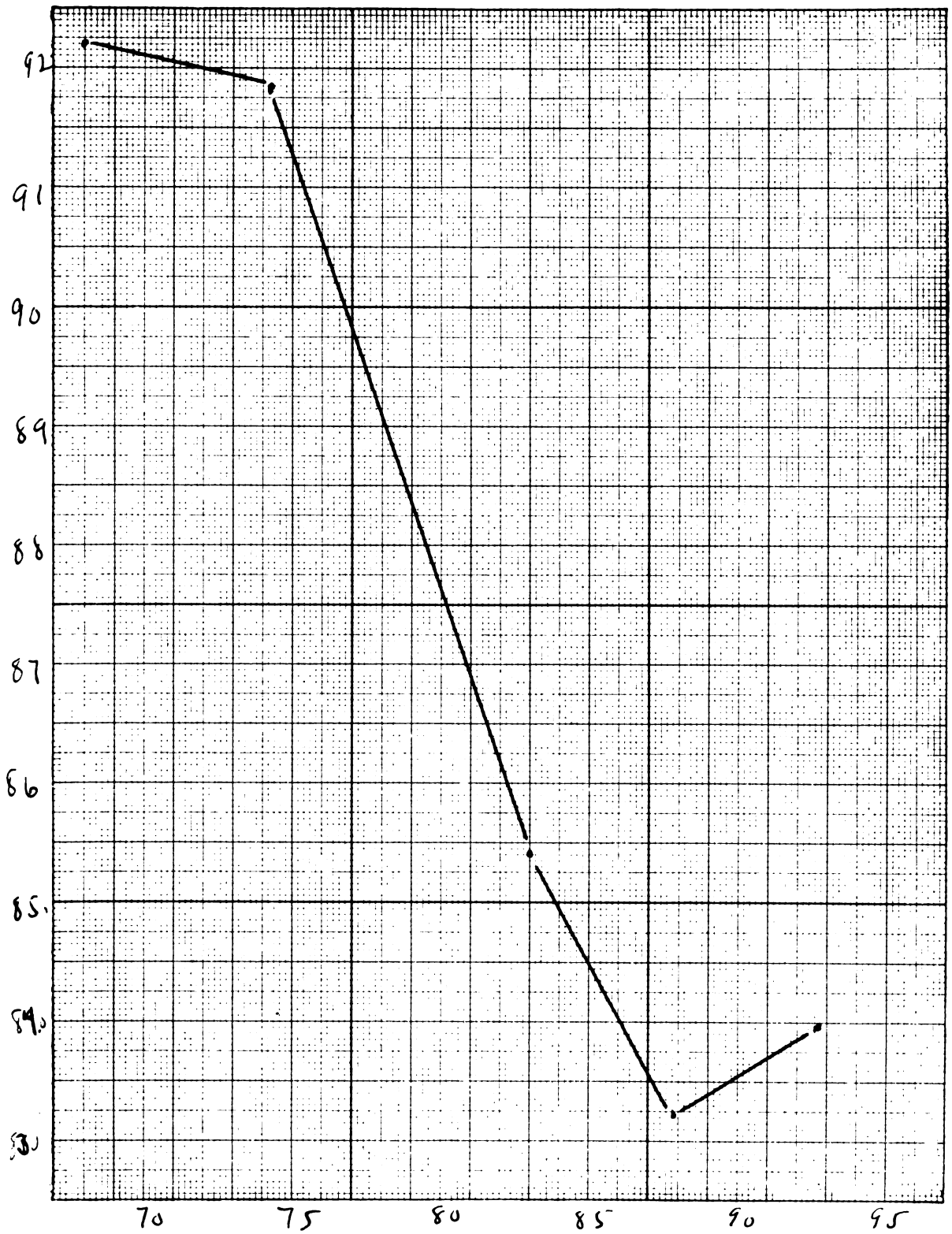
Curve M. Comparison of Males and Females as regards Motor Ability as represented by Motor Index.



Curve N. Comparison of Males and Females with respect to Class Standings.



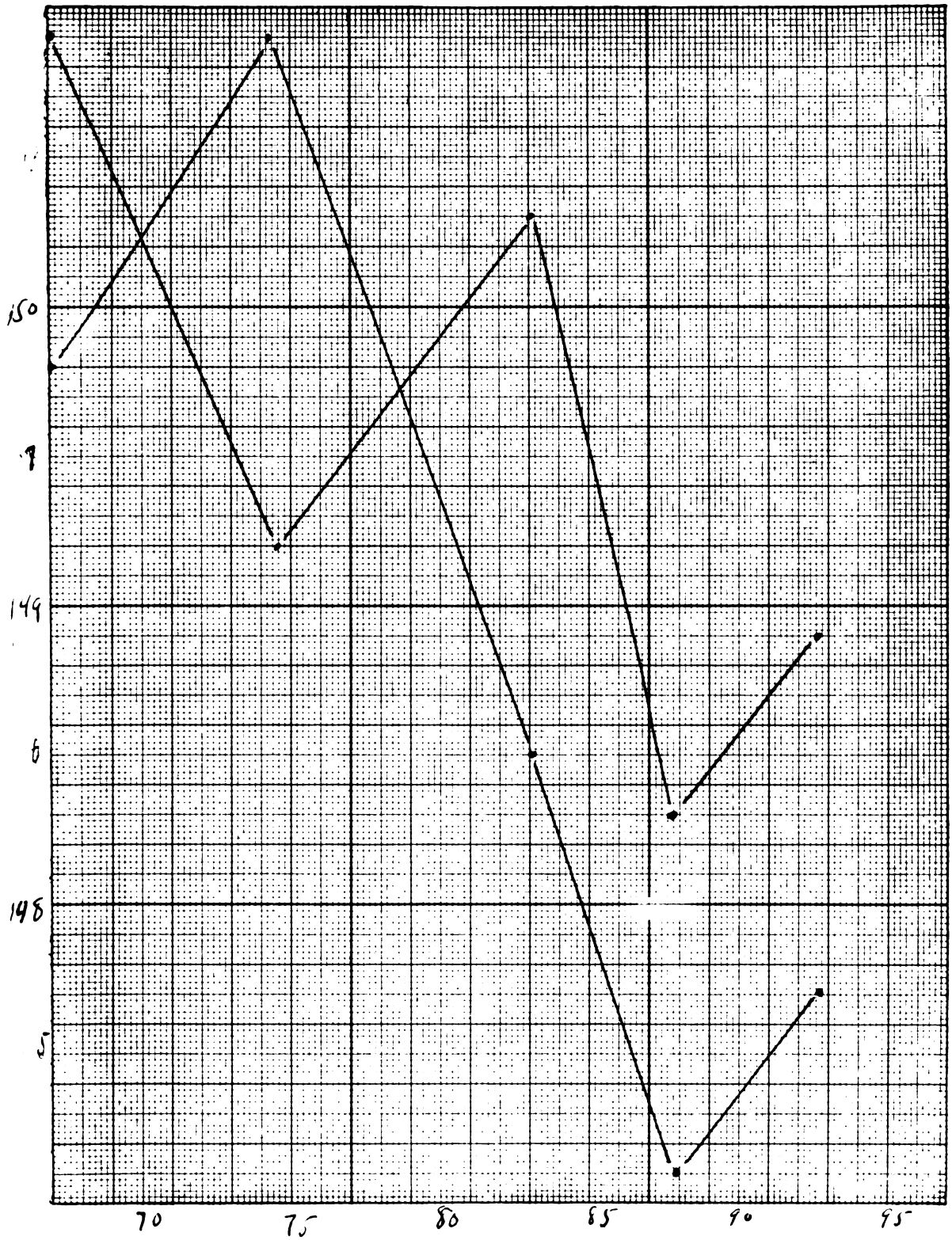
Correlation Curve, O. Single Correlation of Weight and Class Standings.



Abscissa: Standings

Ordinate: Weight.

Correlation Curve, P. Single Correlation of Head Girths and Class Standings.



Abscissa: Standings. Ordinate: Head Girths.

Red Line: Head Length. Black Line: Head Breadth.

-Table No. I-

-Correlation of Test for Strength with Standings-

Class	AA	A	M	X	XX
Dynamometer	72.79	57.1	48.4	39.7	28.9
Standings	75.4	80.	83.97	85.71	82.92

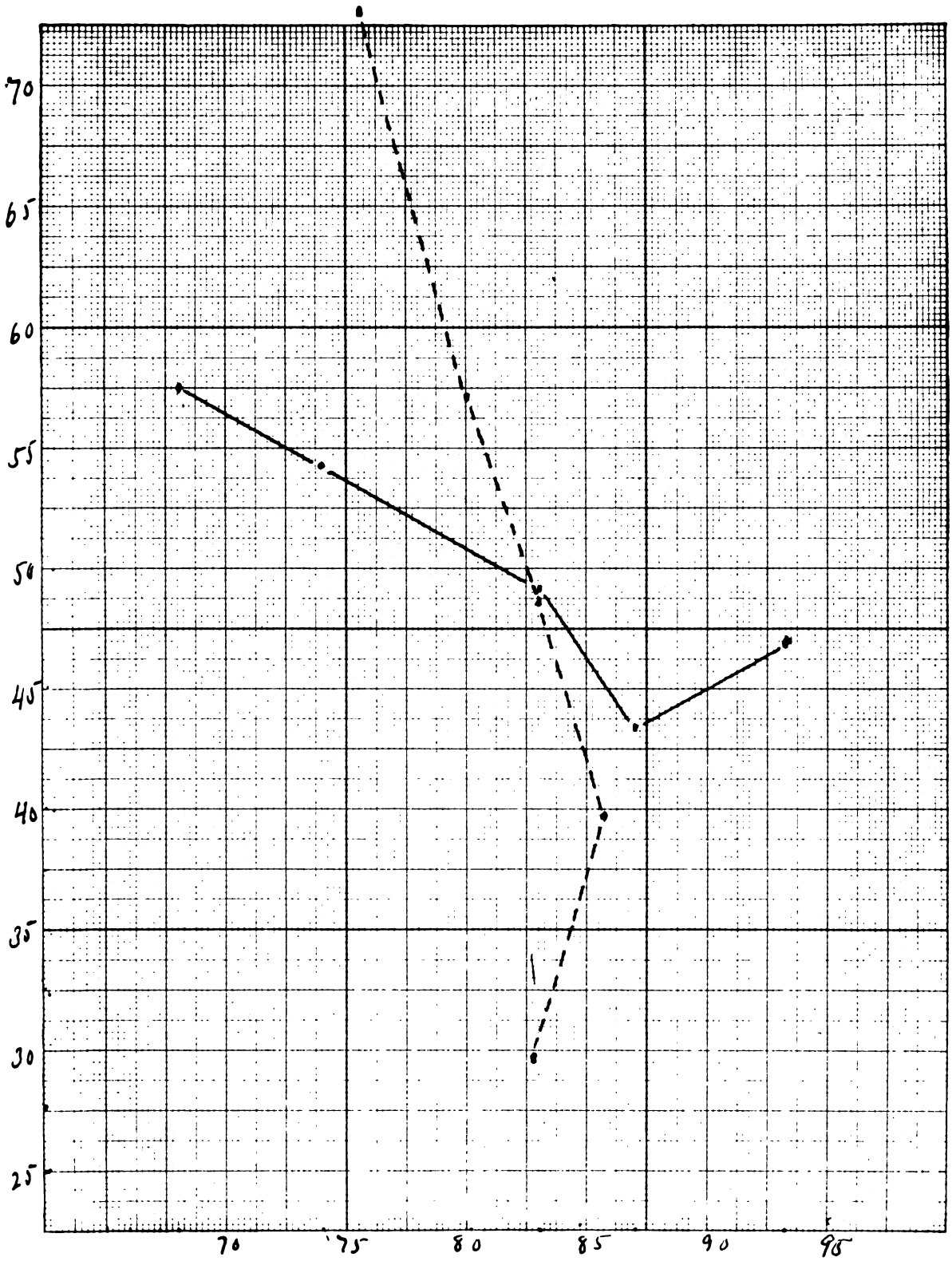
General Average (160 tests):

Dynamometer: 47.97

Standings 81.6

(See Correlation Curve No.I.)

Correlation Curve No. I. Double Correlation of Test for Strength with Class Standings.



Abscissa: Class Standings. Ordinate: Dynamometer (Pounds)

-Table No. II-

-Correlation of the Test for Rapidity with Standings-

Class	AA	A	M	X	XX
Trilling	65.51	56.96	53.89	48.42	40.33
Standings	80.31	82.18	85.90	79.39	79.30

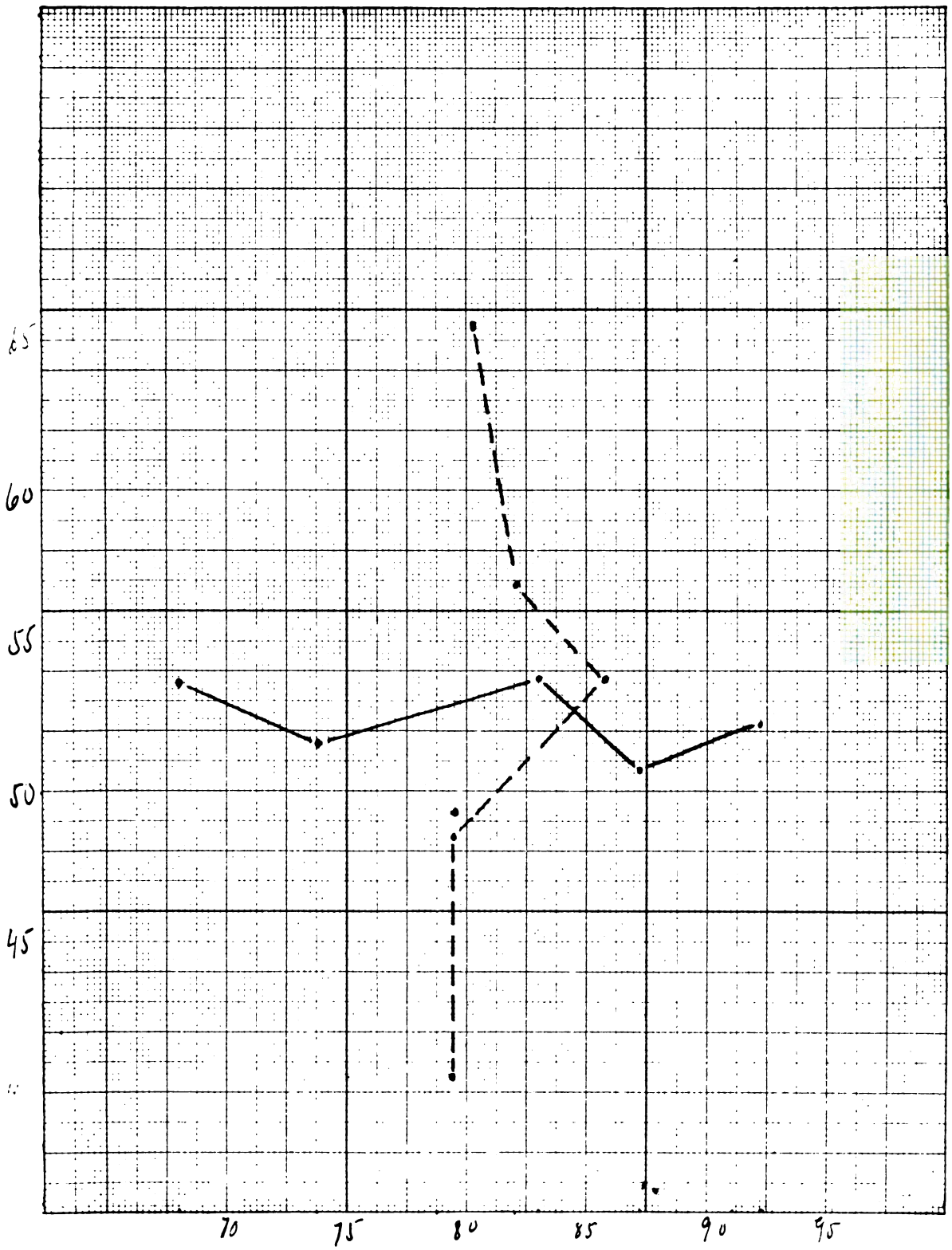
General Averages:

Trilling: 52.72

Standings 81.6

(See Correlation Curve No.II.)

Correlation Curve No. II. Double Correlation of Rapidity test and Class Standings.



Abscissa: Standings. Ordinate: Trilling (Number for ten seconds.)

-Table No. III-

-Correlation of the Steadiness Test with Standings-

Class	AA	A	M	X	XX
Tracing errors	68.6	115.28	145.5	176.7	229.2
Standings	78.10	81.44	77.1	82.45	99.88

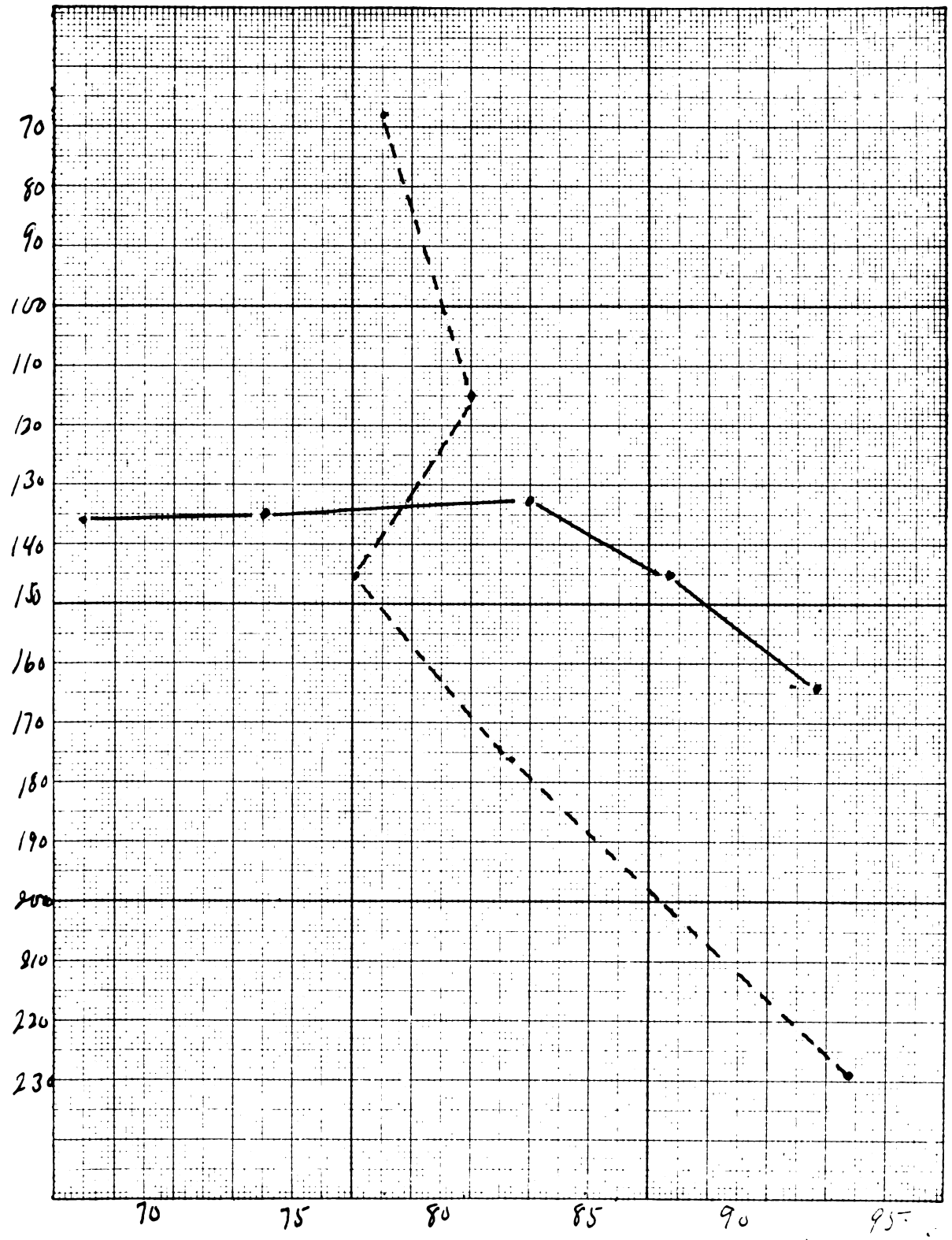
General Averages:

Tracing Errors: 145.65

Standings: 81.6

(See Correlation Curve No. III.)

Correlation Curve No. III. Double Correlation of the Steadiness Test and Class Standings.



Abscissa: Standings. Ordinate: Errors in Tracing.

-Table No. IV-

-Correlation of Accuracy Test with Class Standings-

Class	AA	A	M	X	XX
Constant Error:	74.2	99.3	112.2	127.7	149
	78.3	78.5	84.3	81.8	83.9

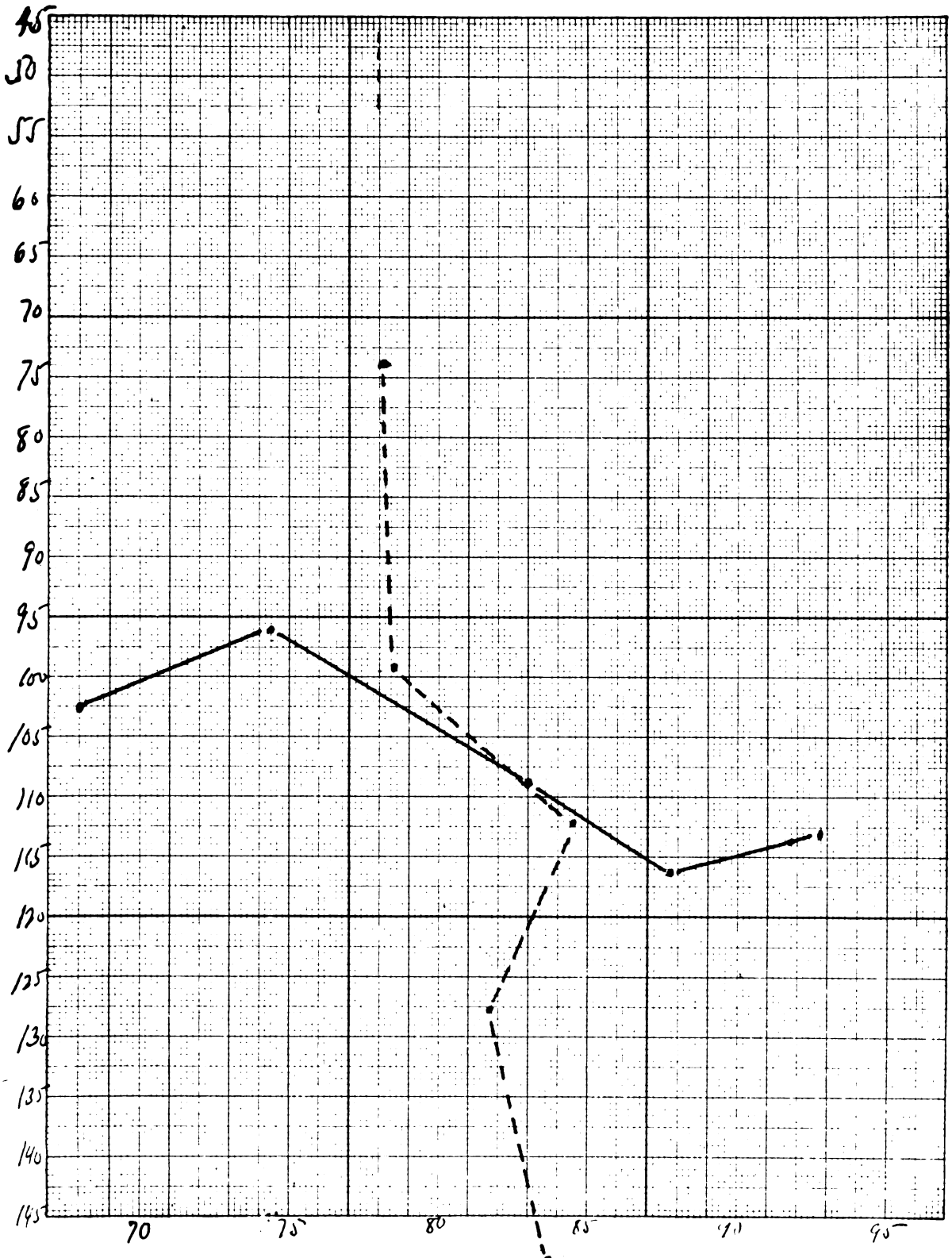
General Averages:

Constant Error: 109.18

Standings 81.6

(See Correlation Curve No. IV.)

Correlation Curve No. IV. Double Correlation of Class Standings and Rapidity Test.



Abscissa: Standings. Ordinate: Constant Error on Target.

-Table No. V-

-Correlation of Constancy Test with Class Standings-

Class	AA	A	M	X	XX
Per c't Av. Er.	29.12	34.3	39.7	42.8	517
Standings	81.51	85.03	76.73	83.50	81.6

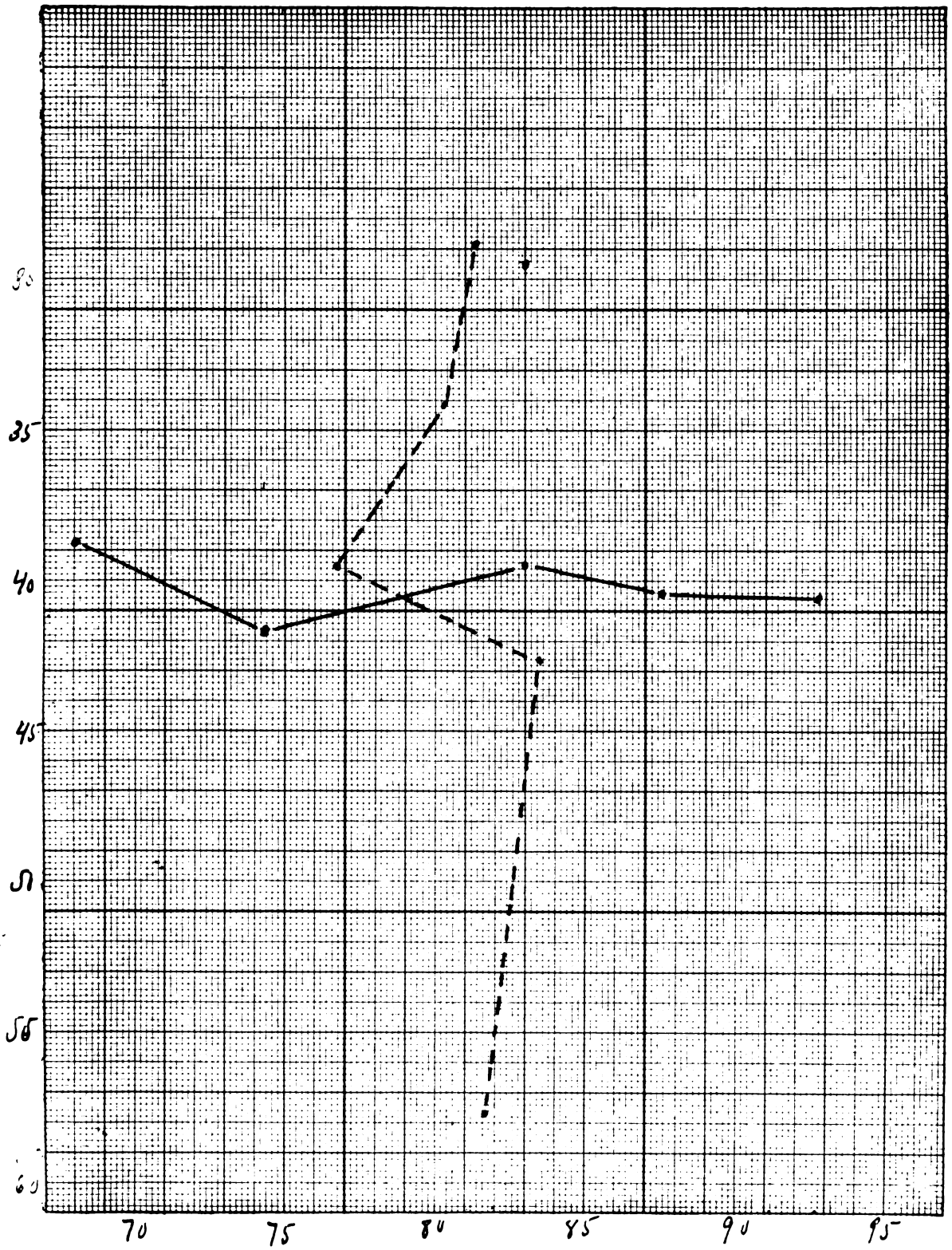
General Averages:

Per cent. of Average Error: 38.68

Standings 81.6

(See Correlation Curve No. V.)

Correlation Curve No. V. Double Correlation of Class Standings and the Test for Constancy.



Abscissa: Standings. Ordinate: Per cent. Average Error.

-Table No. VI-

-Correlation of Test for Involuntary Movement and-
-Standings-

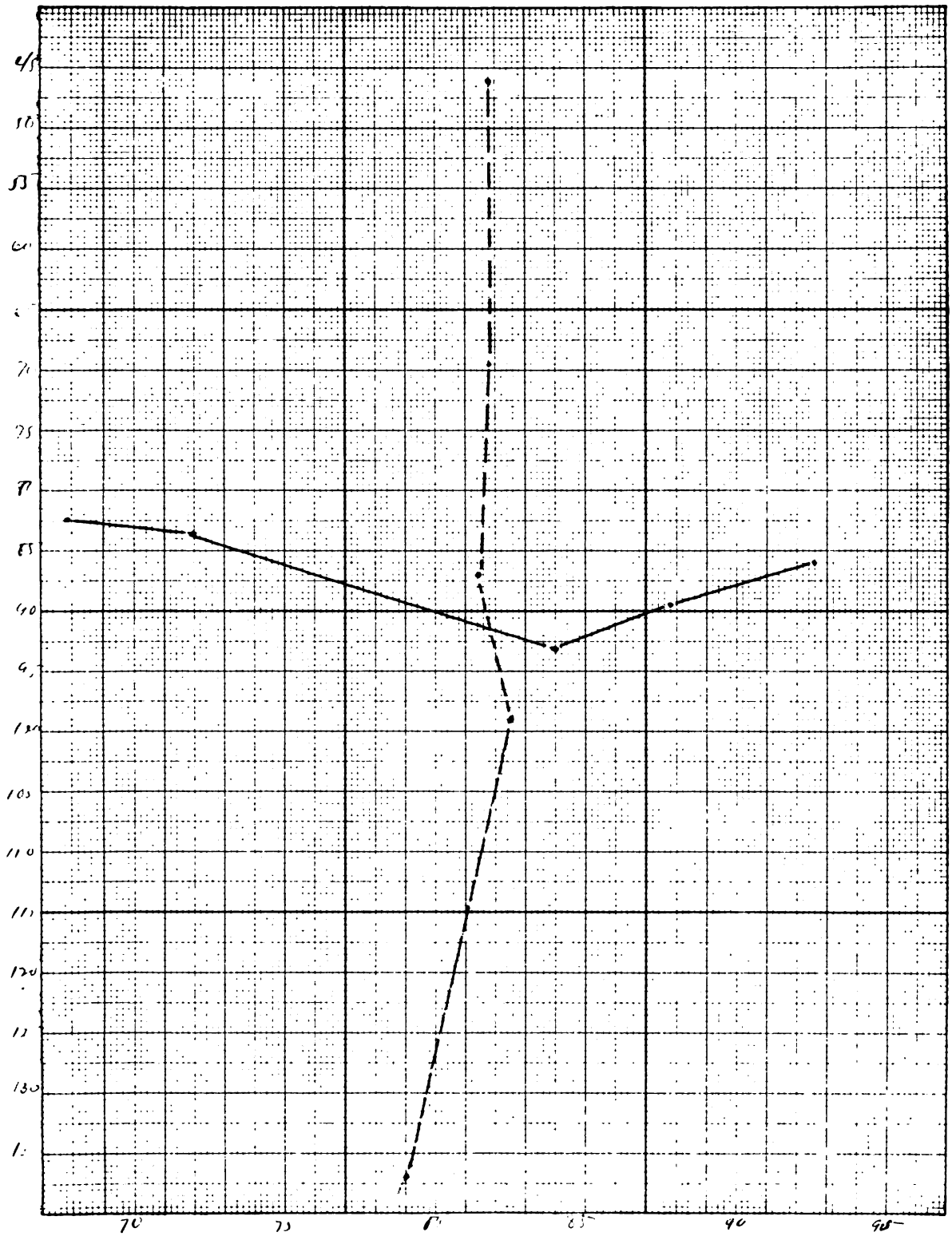
Class	AA	A	M	X	XX
Automatograph	46.3	69.9	86.9	98.9	137. 9
Standings	81.8	81.9	81.4	82.5	79.

General Averages:

Automatograph	88.3
Standings	81.6

(See Correlation Curve No. VI.)

Correlation Curve No. VI. Double Correlation of Class Standings and the Test for Involuntary Movement.



Abscissa: Class Standings. Ordinate: Amplitude of Involuntary Movement.

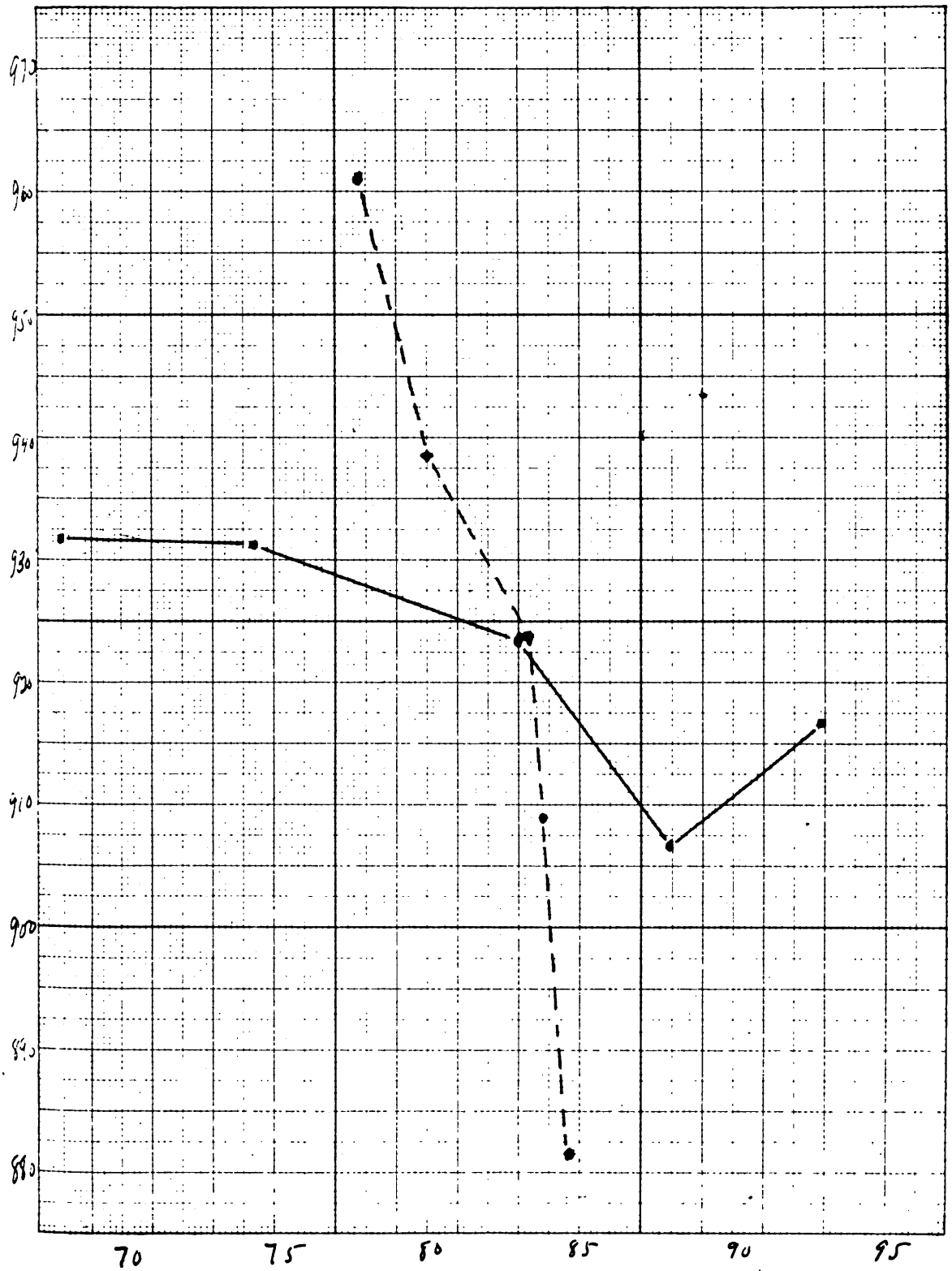
-Table No. VII-

-Correlation of Motor Index with Class Standings-

Class	AA	A	M	X	XX
Motor Index	961.8	938.3	924.3	909	881.9
Standings	77.8	80.	83.6	83.8	84.7

(See Correlation Curve No. VII.)

Correlation Curve No. VII. Double Correlation of Class Standings and Motor Index.



Abscissa: Class Standings. Ordinate: Motor Index.

-Table No. VIII-

-Correlation of Class Standings with various Motor-
-Tests-

Class	AA	A	M	X	XX
STANDINGS	92.7	87.5	83.	74	67.9
Dynamometer	47	43.5	49.1	54.3	56.8
Trilling	52.3	50.7	53.4	51.6	53.6
Tracing	164.8	145	133.1	135.1	136.3
Accuracy Test	113.1	116.2	108.4	95.9	102.5
Automatograph	86.	83.2	93.4	83.6	82.8
Constancy Test	40.5	40.3	39.5	41.8	38.9
MOTOR INDEX	917.2	907.1	922.8	931.	931.05

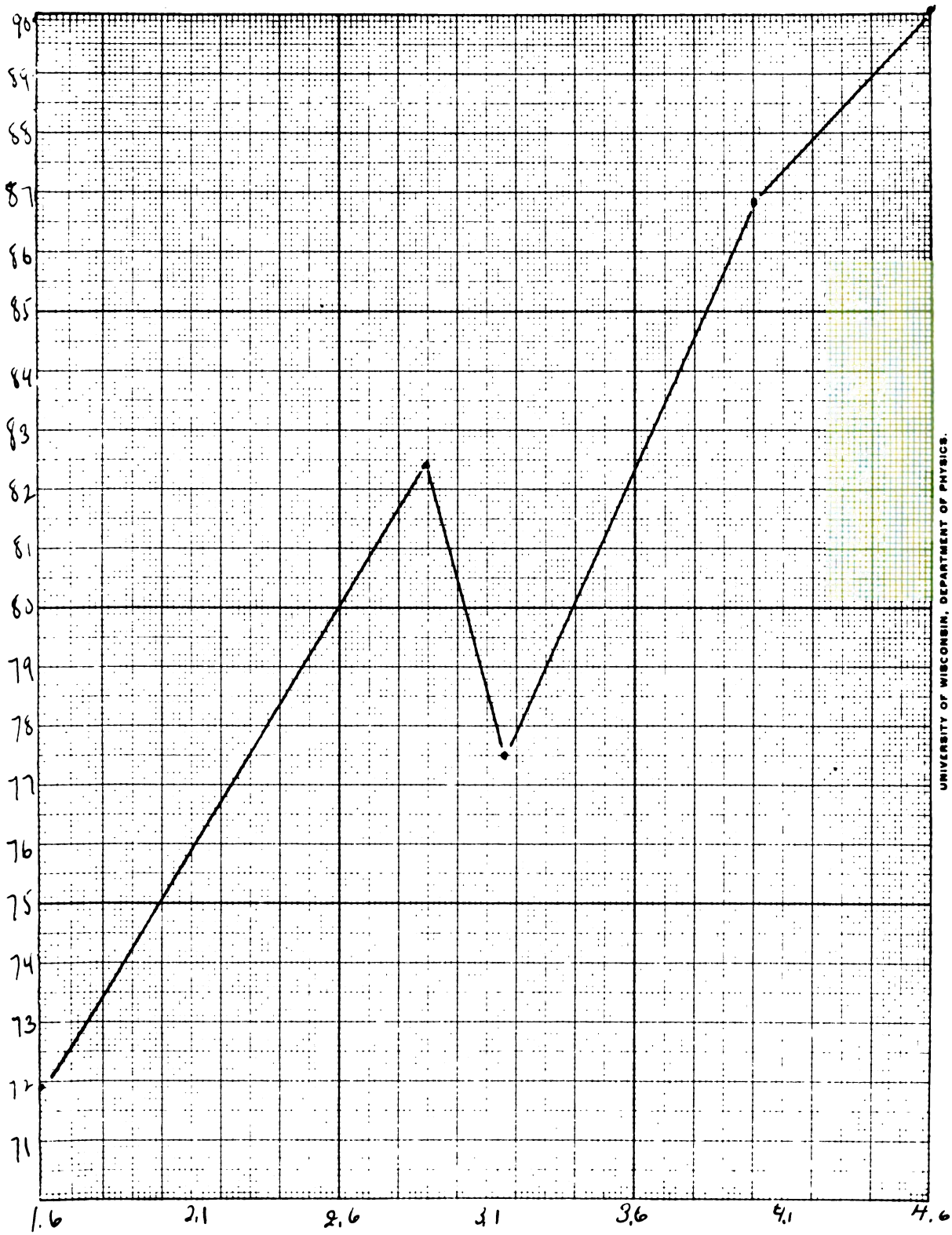
-Table No. IX-

-Correlation of Teachers' Estimates with Standings-

Class	AA	A	M	X	XX
Mental Ability	4.62	4.	3.16	2. 87	1.59
Standings	90.5	86.28	77.	82.43	71.9

(See Correlation Curve No. IX.)

Correlation Curve No. IX. Single Correlation of Teachers' Estimates of Mental Ability and Class Standings.



Abscissa: Teachers' Estimates. Ordinate: Standings.

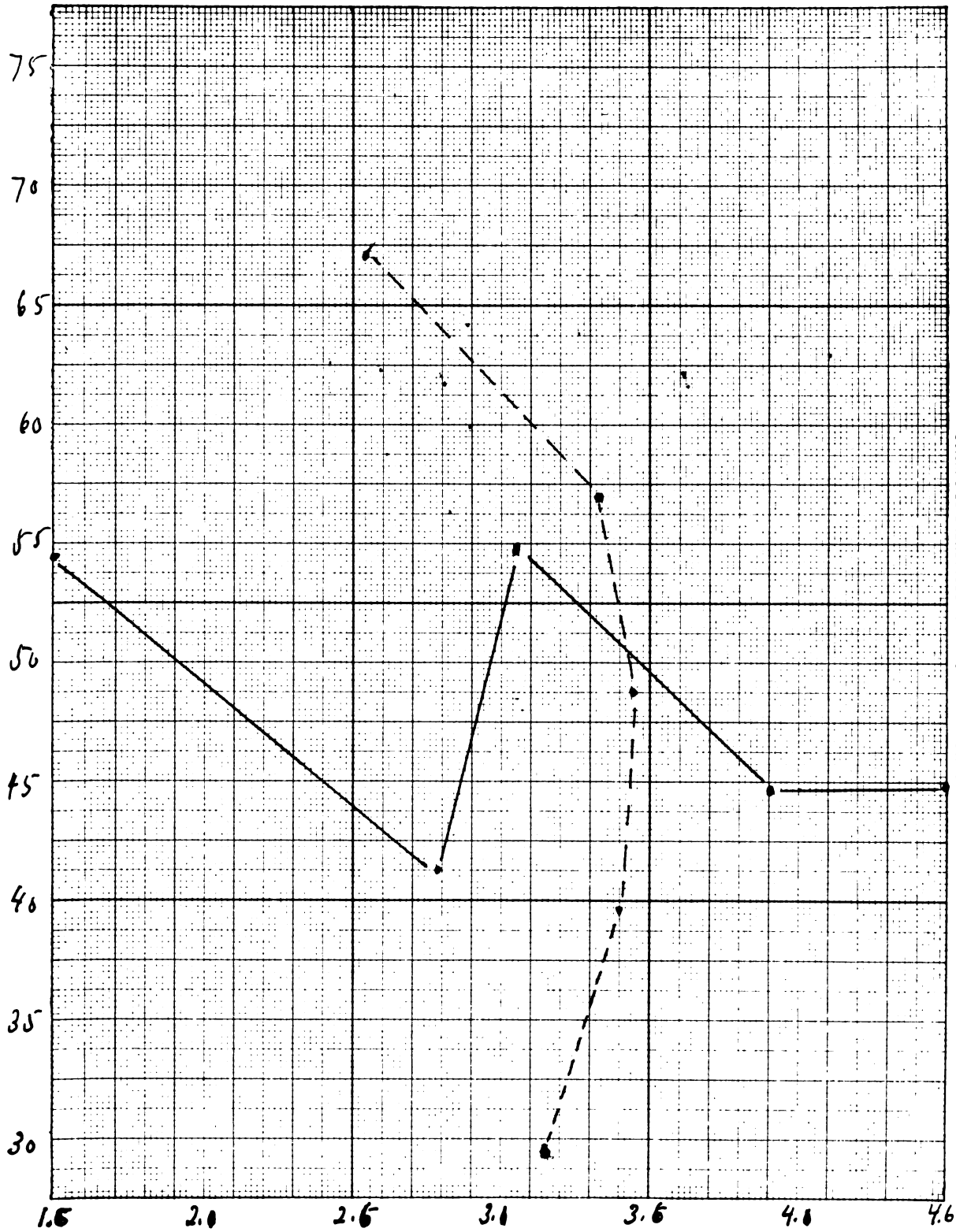
-Table No. X-

-Correlation of Dynamometer with Teachers' Estimate-
-of Mental Ability-

Class	AA	A	M	X	XX
Dynamometer	72.9	57.1	48.4	39.7	28.9
Estimates	2.64	3.43	3.56	3.50	3.24

(See Correlation Curve No. X.)

Correlation Curve No. X. Double Correlation Of Teachers' Estimates and Test for Strength.



Abscissa: Estimates. Ordinate: Pounds on Dynamometer.

-Table No. XI-

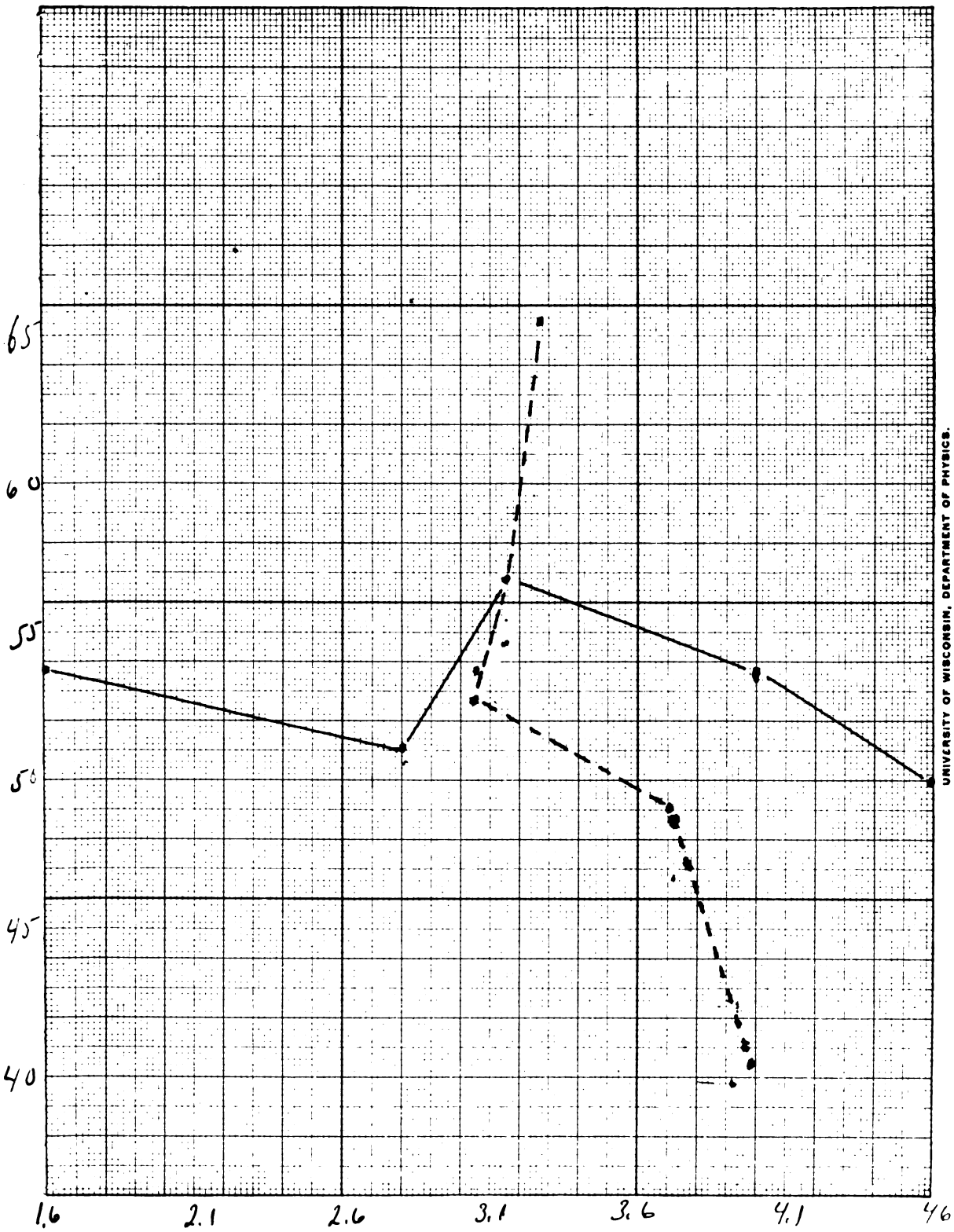
-Correlation of Rapidity Test with Teachers' Estimates-

-of Mental Ability-

Class	AA	A	M	X	XX
Trilling	65.5	56.26	53.89	48.42	40.33
Estimates	3.29	3.15	3.06	3.7	3.99

(See Correlation Curve No. XI.)

Correlation Curve No. XI. Double Correlation of Teachers' Estimates and the Test for Rapidity.



Abscissa: Estimates. Ordinate: Trilling (Number for ten Seconds.)

-Table No. XII-

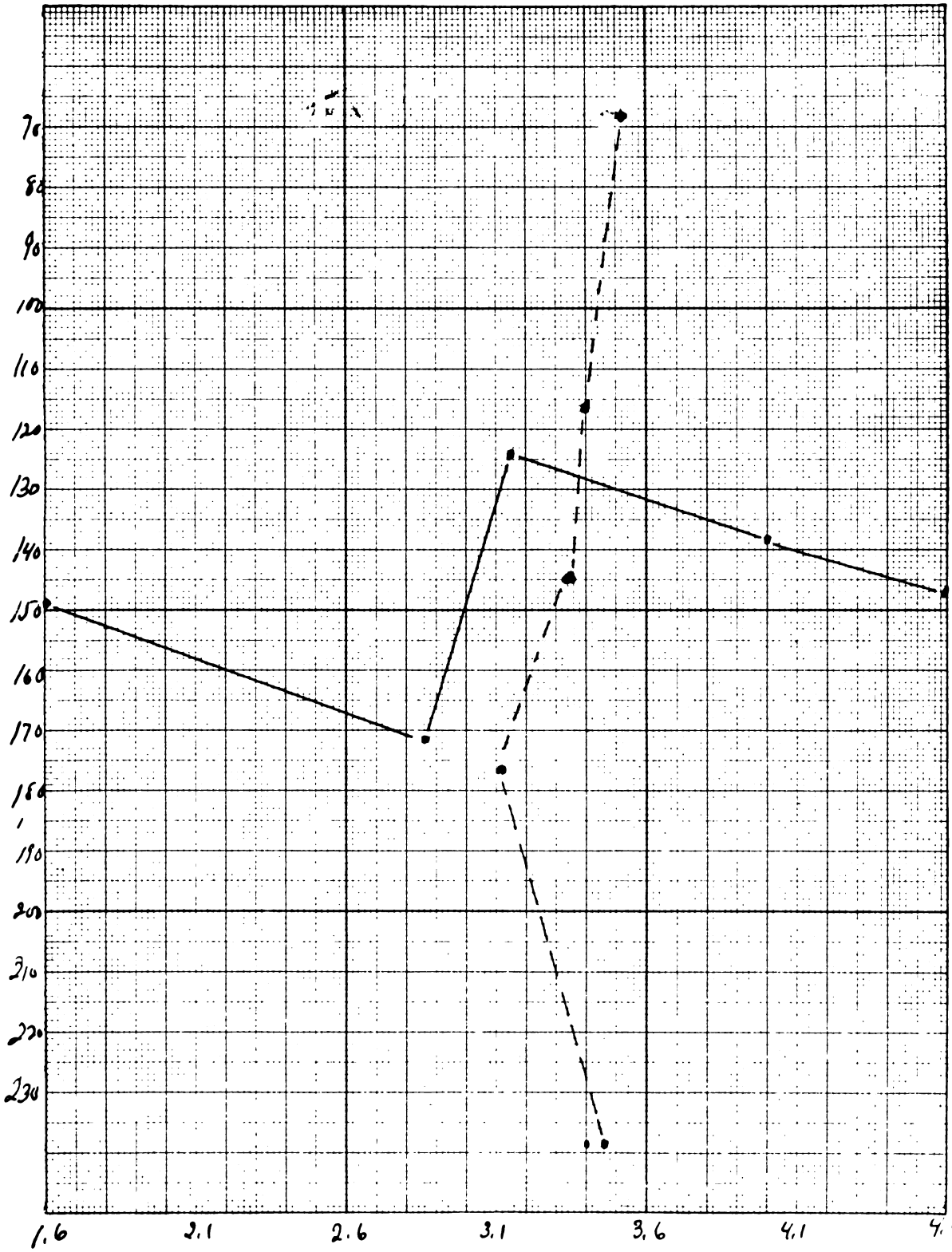
-Correlation of Steadiness Test with Teachers' Estimates of Mental Ability.

Class	AA	A	M	X	XX
Tracing Errors	68.6	115.28	145.5	176.7	229.24
Estimates	3.51	3.4	3.34	3.12	3.41

(See Correlation Curve No. XIII.)

Correlation Curve no. XII. Double Correlation of Teachers'

Estimates and the "Steadiness" Test.



Abscissa: Estimates. Ordinate: Errors in Tracing.

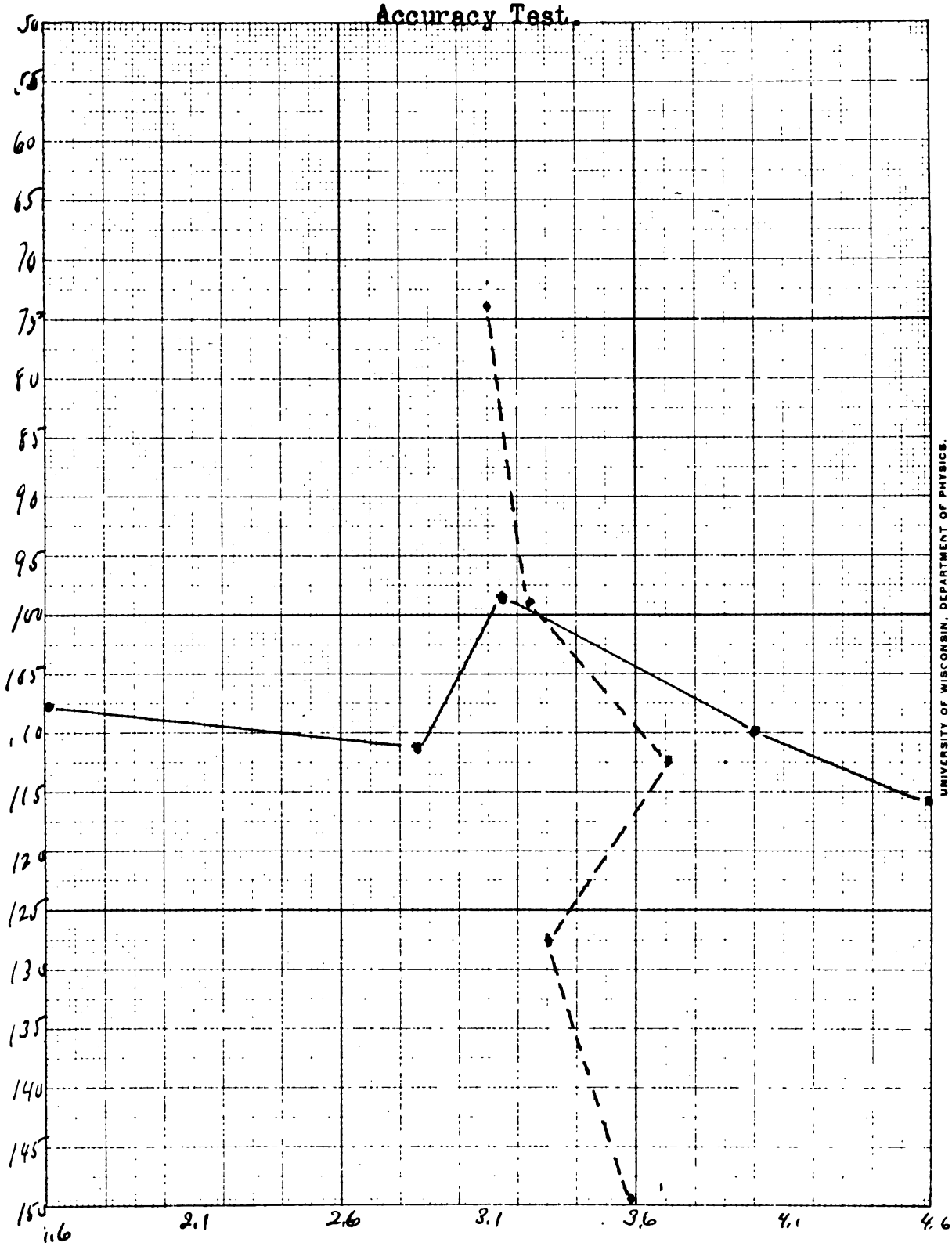
-Table No. XIII-

-Correlation of Accuracy Test with Teachers' Estimates-
-of Mental Ability-

Class	AA	A	M	X	XX
Accuracy Test	74.2	99.3	112.2	127.7	149.
Estimates	3.12	3.21	3.71	3.33	3.59

(See Curve No. XIII.)

Correlation Curve No. XIII. Double Correlation of Teachers' Estimates and Accuracy Test.



Ascisaa: Estimates. Ordinate: Constant Error on Target:

-Table No. XIV-

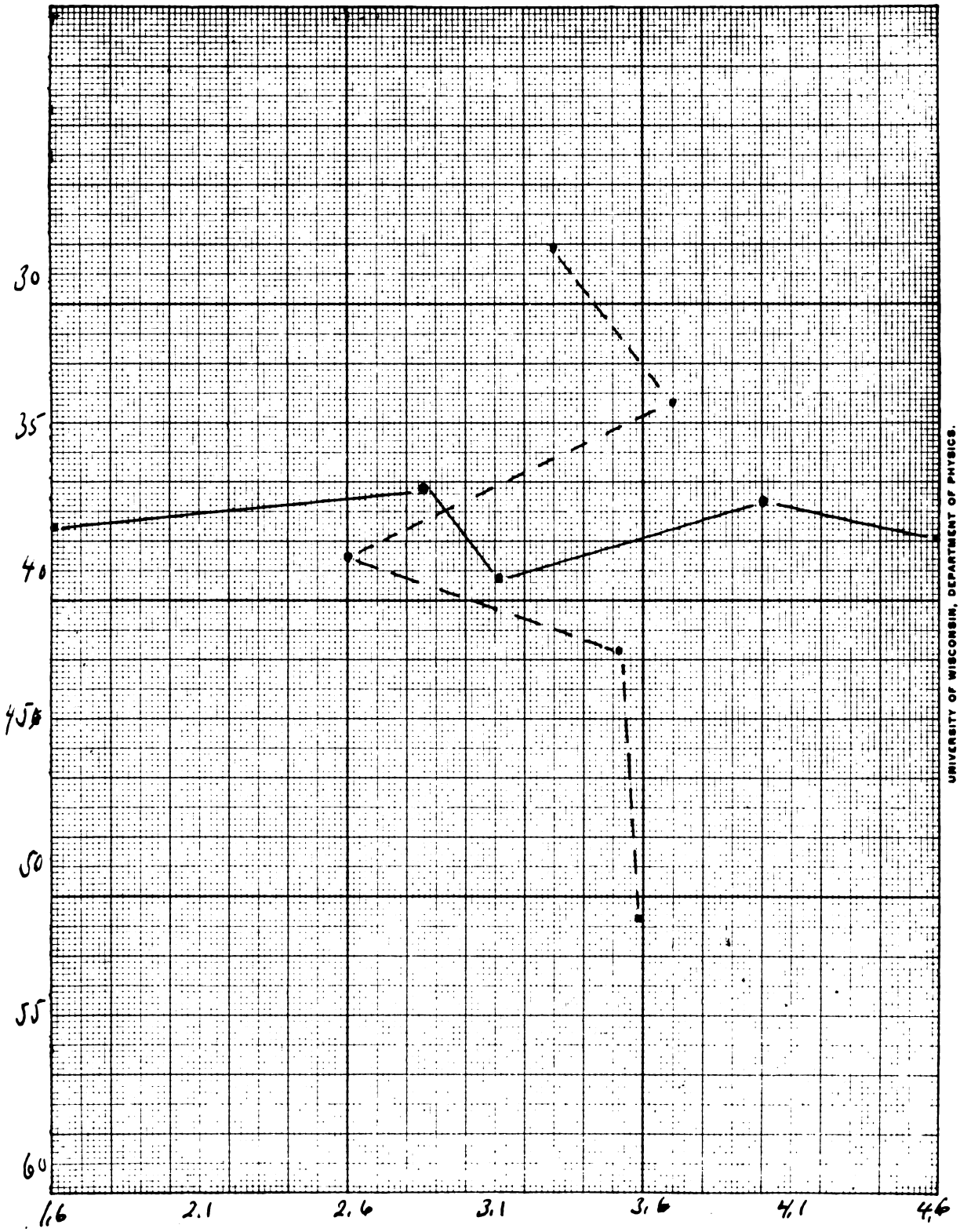
-Correlation of Constancy Test with Teachers' Estimates-

-of Mental Ability-

Class	AA	A	M	X	XX
Per Cent Av.Er.	29.12	34.3	39.7	42.8	51.7
Estimates	3.35	3.7	2.6	3.53	3.59

(Correlation Curve No. XIV.)

Correlation Curve No. XIV. Double Correlation of Teachers Estimates with the Test for Constancy.



Abscissa: Estimates. Ordinate: Percent. Average Error.

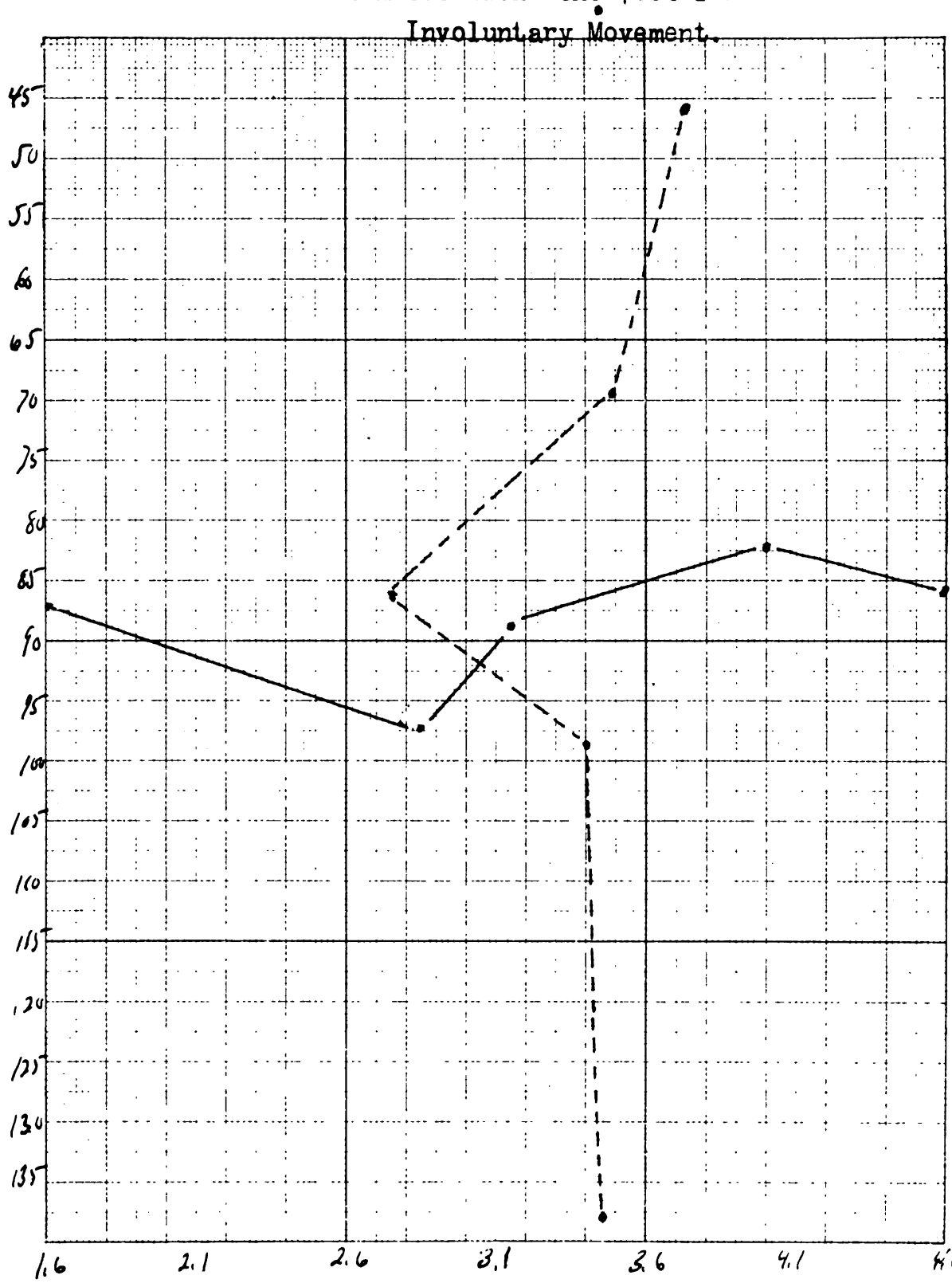
-Table No. XV-

-Correlation of Automatograph Test with Teachers'
-Estimates of Mental Ability-

Class	AA	A	M	X	XX
Automatograph	46.3	69.9	86.9	98.9	137.8
Estimates	3.66	3.49	2.75	3.40	3.45

(See Curve No. XV.)

Correlation Curve No. XV. Double Correlation of Teachers' Estimates with the test for Involuntary Movement.



Abscissa: Estimates. Ordinate: Amplitude of Involuntary

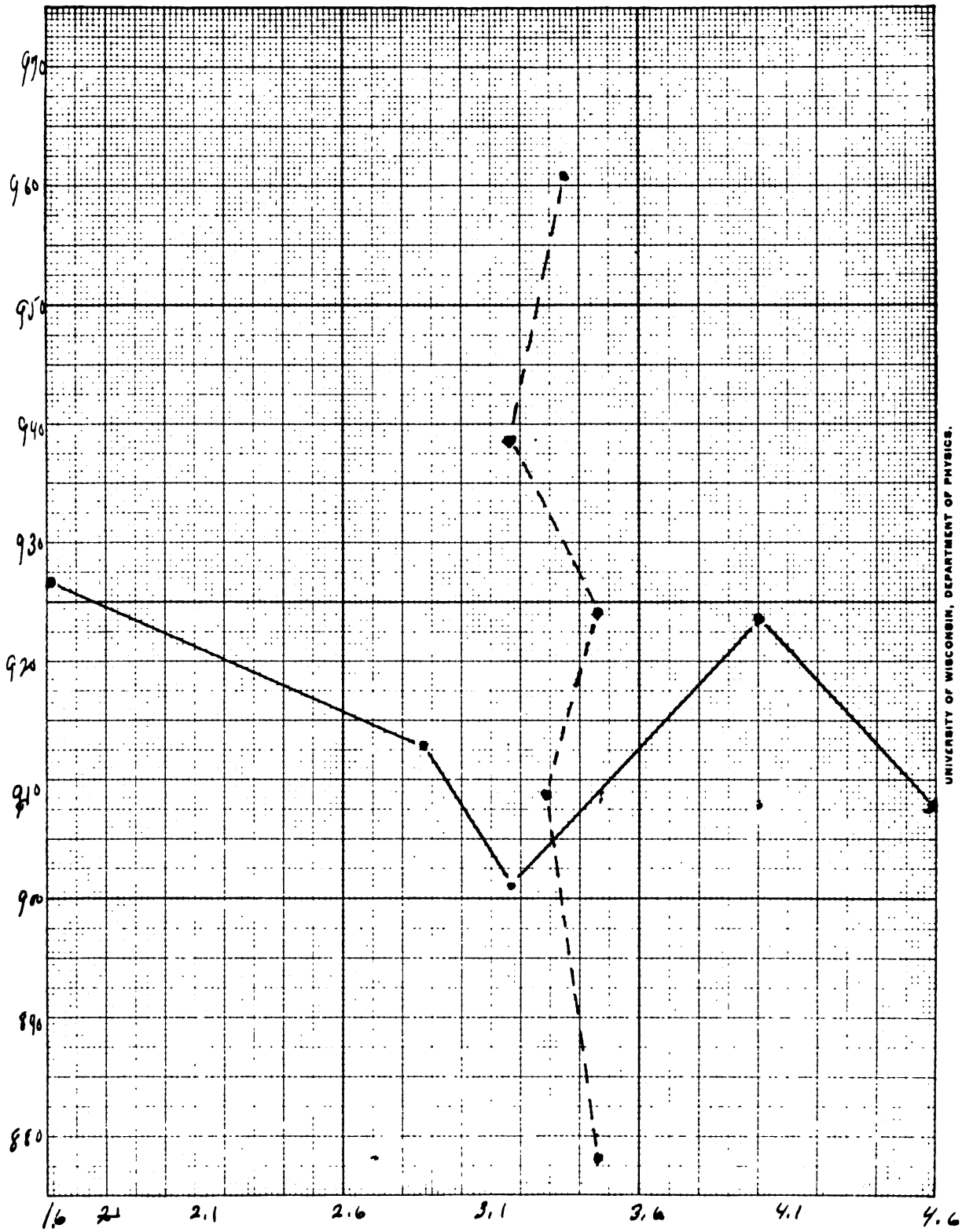
-Table XVI-

-Correlation of Motor Index with Teachers' Estimates-
-of Mental Ability-

Class	AA	A	M	X	XX
Motor Index	961.8	938.3	924.3	909.	881.9
Estimates	3.32	3.15	3.46	3.36	3.34

(See Curve No. XVI.)

Correlation Curve No. XVI. Double Correlation of Teachers' Estimates and Motor Index.



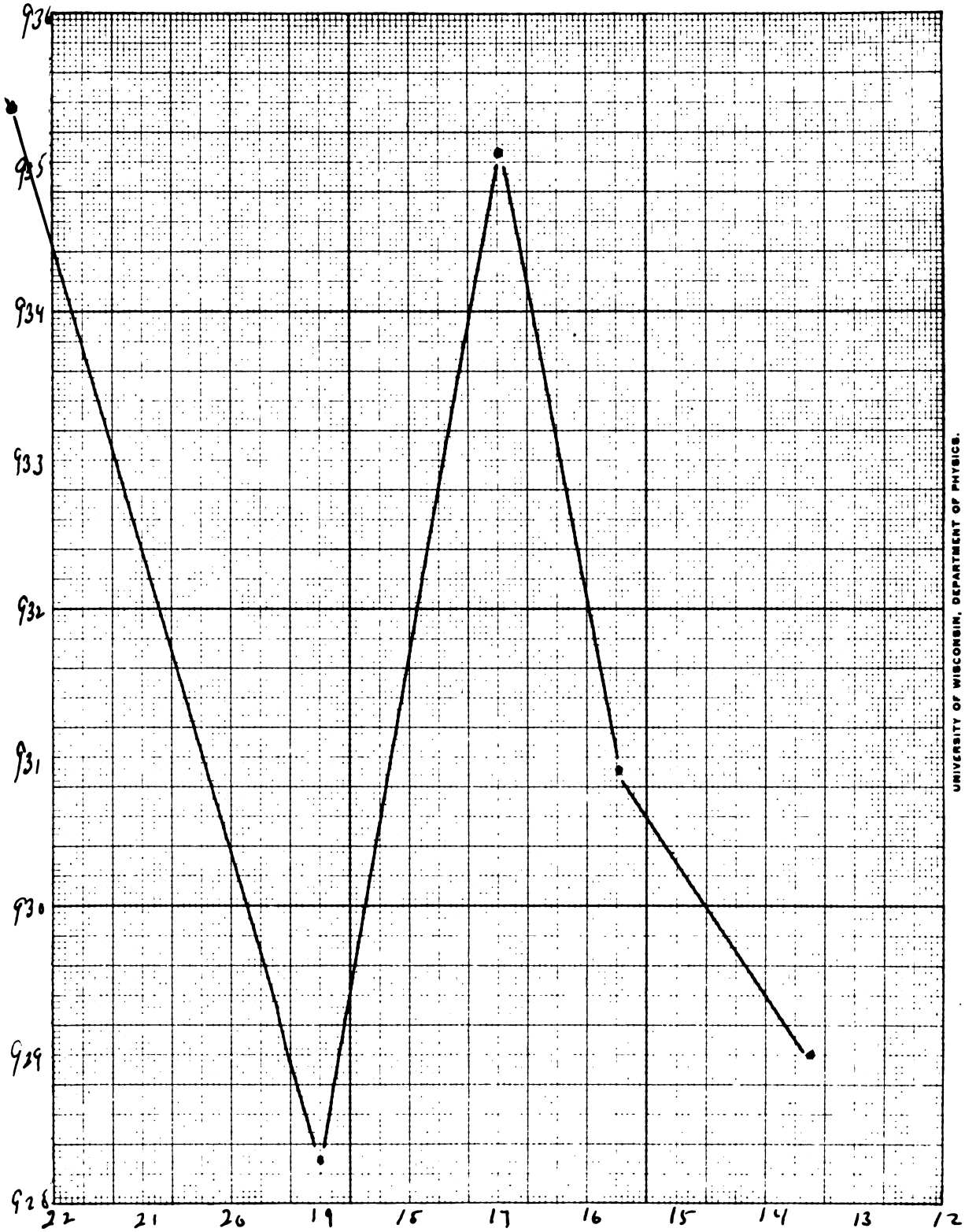
Abscissa: Estimates. Ordinates: Motor Index.

-Table No. XVII-

-Correlation of Teachers' Estimates of Mental Ability-
-with various Motor Tests-

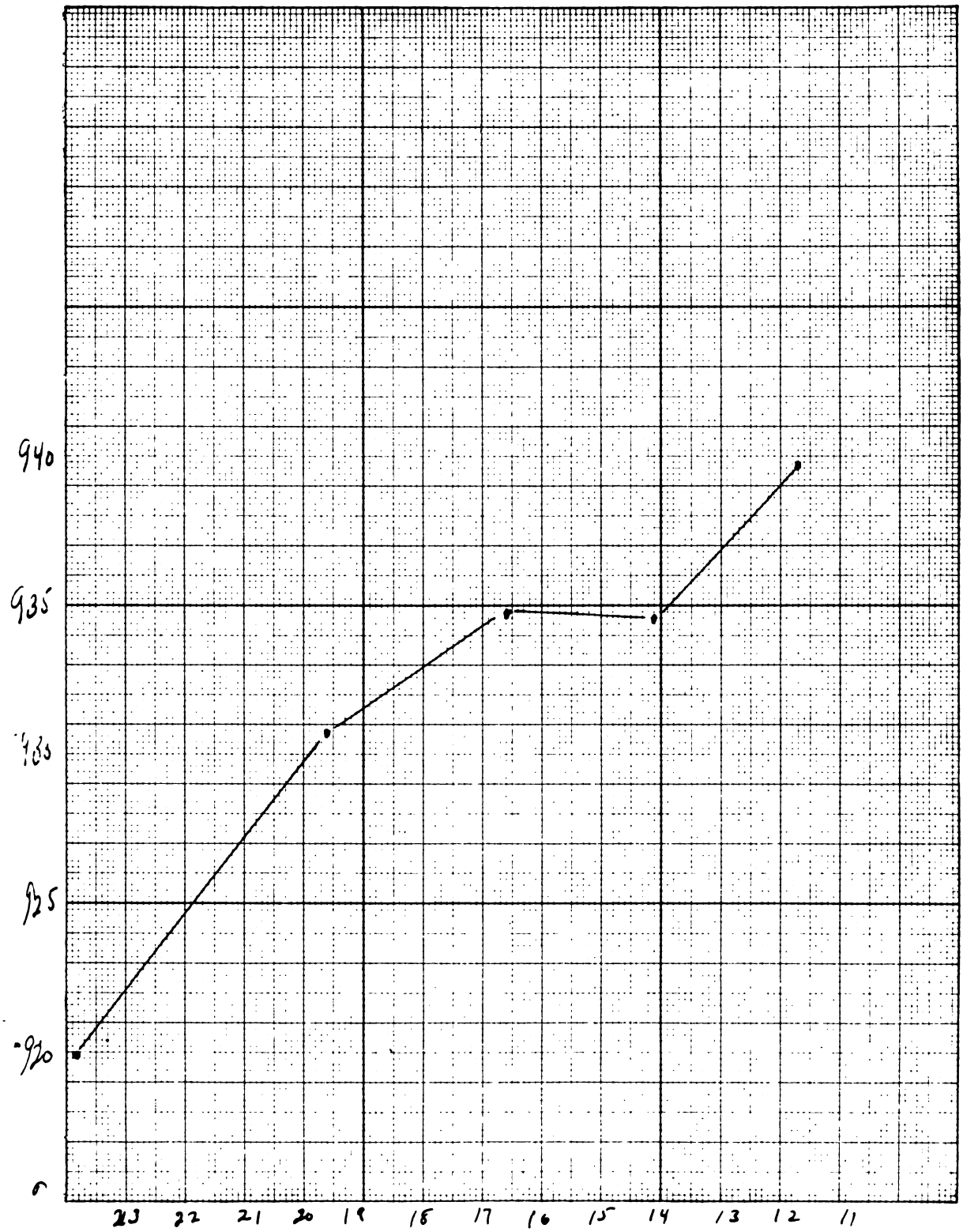
Class	AA	A	M	X	XX
ESTIMATES	4.62	4.	3.16	2.87	1.99
Test of Strength	44.9	44.83	54.41	41. 31	71.9
Rapidity	50	52.9	55.84	51.06	53.8
Steadiness	146.2	138.0	124.09	170.8	149.2
Accuracy	115.8	109.5	101.86	111.06	108.
Constancy	38.9	37.4	41.24	37.1	38.8
Automatograph	85.6	84.2	87.62	97.4	87.1
Motor-Index	908.	924.4	901.6	913.3	926.8

Curve No. XVII. Single Correlation of Mental Alertness (Reaction Times) and Motor Index.



Abscissa: Mental Alertness. Ordinate: Motor Index.

Curve No. XVIII. Single Correlation of "Handling Time" and Motor Index.



Abscissa: Handling time. Ordinate: Motor Index.